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AIR FORCE MANUAL

INTELLIGENCE

PHOTOGRAPHIC INTERPRETATION KEYS

UNDERGROUND INSTALLATIONS

MAY 1954

DEPARTMENT OF THE AIR FORCE

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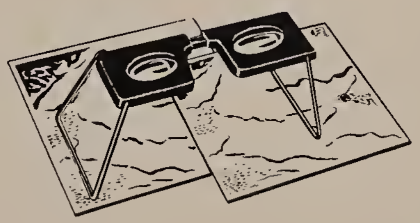

1 May 1954

DEPARTMENT OF THE AIR FORCE

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AIR FORCE MANUAL
NO. 200–35

DEPARTMENT OF THE AIR FORCE
WASHINGTON, 1 May 1954

Foreword

1. Purpose and Scope. This Manual provides Air Force intelligence and operations units with one of a series of keys for rapid and accurate reading and interpretation of aerial photographs. This particular key is intended for use as a subject key for underground installations, including those designed for critical industries and stockpiles.

2. Utilization. This Manual will be utilized as a text in photographic intelligence officer and airman schools and will serve also as a reference for intelligence, operations, and logistics personnel concerned with military activities in areas which contain underground installations.

3. Source. The material presented herein is a result of many years of photographic intelligence research utilizing comparative photography, captured documents, and ground check to verify the results.

4. Changes. Proposed changes to the Manual will be submitted through appropriate channels to the Director of Intelligence, Headquarters USAF, ATTENTION: Reconnaissance Branch, Washington 25, D. C.

BY ORDER OF THE SECRETARY OF THE AIR FORCE:

N. F. TWINING
Chief of Staff, United States Air Force

OFFICIAL:

K. E. THIEBAUD
Colonel, USAF
Air Adjutant General

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This Manual supersedes AFM 200–35, 1 November 1953.

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Contents

Page

Historical Background 1

Interpretation Keys 7
  Test Borings 8
  Tunnel Entrance 11
  Spoil 16
  Narrow Gauge Railway 19
  Standard Gauge Railway 23
  Roads and Paths 25
  Aerial Tram and Cableways 26
  Buildings 29
  Barracks 32
  Guard Towers 33
  Protective Wire 34
  Protective Construction 35
  Camouflage 41
  Open Air Storage 45
  Cranes and Hoists 46
  Construction Equipment 51
  Sand and Gravel Pits 56
  Shaft House 57
  New Shaft 60

Page

Interpretation Keys (Cont'd)
  Smoke Stack 63
  Ventilation Shafts 64
  Power 70
  Water 72
  Sewage 74
  Test Facilities 75
  Finished Products 76

Types of Sites
  New Tunnels 86
  Hillside Mines 92
  Vertical Shaft Mine 99
  Railway Tunnels 101
  Highway Tunnels 102
  Beer Storage Tunnels 103
  Mushroom Culture Tunnels 104
  Water Tunnels 106
  Natural Caves 107
  Cellars 109
  Bunkers 112

HISTORICAL BACKGROUND

Even though underground sites have been used by mankind for various purposes for thousands of years, for example, caves as dwelling places by prehistoric men, the Catacombs for burial places by the early Christians, tunnels for the storage and ageing of beer, cheese, wine, and champagne, the Maginot Line for military defense, and natural caves for recreational purposes throughout the world, to mention only a few examples, it was not until World War II that underground sites were used on a large scale to protect industrial facilities from destruction by aerial bombardment. A few underground industrial installations were built in Europe before the war: the Skoda bunker-type armament plant at Dubnica, Czechoslovakia; two hydroelectric power plants in a mine at Clausthal, Germany; the W.I.F.O. oil storage depot in new tunnels at Niedersachswerfen, Germany; an aircraft factory in a mine at Cravant, France; and artillery shell filling plants and storage depots in many deep salt mines in Germany; however, these were not enough to affect materially the defensive capabilities of the countries involved.

Semi-underground petroleum storage depots of the dispersed-buried-tank type and explosive works of the dispersed-mounded and revetted-igloo type were fairly common before World War II. These were built mainly to reduce the danger of fire and explosions and offered only limited protection against aerial bombardment. In fact, very few real underground factories were built until 1944. Before that date one of the main inactive defense measures adopted in Germany was above-ground dispersal of normal expansion of industry, although this was applied almost solely to the aircraft industry. During the expansion of the German aircraft industry from 1933 to 1942 approximately 58 new aircraft factories (both airframe and engine plants) were built above ground. These were dispersed geographically, were built away from large cities and other potential targets, and plant buildings were not permitted to be larger than a specified size or closer together than a certain distance. However, these above-ground dispersal plants were successfully located by Allied Intelligence and were heavily bombed in 1943 and 1944. Following the devastating attacks of February 1944, in which 15 plants were bombed in one week, 32 of these aircraft factories were relocated and the various departments thereof dispersed to 729 separate sites, both above ground and underground. Of these above ground dispersal plants, a total of 146 were bombed in 1944. By the end of the war there were more than 108 underground aircraft factories planned or under construction of which 78 are known to have reached some stage of production. This included nearly all of the jet fighter production. The plan in November 1944, called for 48,151,000 square feet of underground floor space for the aircraft industry. This was equivalent to approximately 80 million square feet above ground because of closer space planning. Before the bombings of 1943, the German aircraft industry had 53,900,000 square feet of floor space as compared with 250,000,000 square feet utilized by the American aircraft industry during World War II. By January 1945, a total of 12,912,000 square feet of underground floor space had been completed for the German aircraft industry. This was accomplished in less than 14 months mainly by the conversion of mines, caves, highway tunnels, railway tunnels, beer storage tunnels and cellars. Many newly excavated sites were under construction when the war ended but few of them were completed in time to get into production. The small underground dispersals suffered from some of the disadvantages and weaknesses inherent in any program for the extreme decentralization and dispersal of industry, mainly inefficiency of operation and an increase in transportation requirements. The vulnerability of transport was intensified by the loss of air superiority which was in part due to the bombardment of the former above-ground factories. The trend toward the end of the war was to restore efficiency of production and to reduce transportation requirements by reconcentrating the aircraft industry in large newly excavated underground sites. These were being supplemented by the large reinforced concrete semi-underground Bunkerwerke as exemplified by the installations at Muhldorf and Landsberg.

Other types of armament plants were also placed underground in Germany. A grand total of 96,502,900 square feet of underground floor space for strategic industrial plants, including the aircraft industry, was planned. Of this total 73,337,000 square feet were under construction and 14,085,000 square feet were completed when the war ended. The German program included approximately 250 underground factories, including aircraft plants. Of this total at least 227 factories were in production or under construction while the remainder were in an advanced planning stage. In addition, there were other types of underground installations in use: storage depots, military headquarters, a hospital, and air raid shelters, both tunnel shelters and cellars.

The photo reconnaissance and photo interpretation of the German underground installations were carried out mainly by units located in England although some work in this field was done by units in Italy and later by units on the Continent. In October 1944, nearly nine months after the Germans had started their underground program, a special underground section was organized at the Allied Central Interpretation Unit (ACIU) at RAF Station Medmenham, England. This section was known as B-6 Section although its reports were entitled U. Reports. B-6 Section had a maximum strength of seven interpreters and two cartographers as well as the part time services of a geologist. Other sections at ACIU were also available for consultation and assistance. All members of B-6 were British personnel except for one American, the author of this Manual. Before the B-6 Section was organized a number of ground reports were received indicating that the Germans were embarking on a large scale underground program. Some photo interpretation work was done by Industry Section as a result of these reports, principally on the large V-2 factory in production at Niedersachswerfen, and by Aircraft Section on a large factory being excavated in a hill at Langenstein. As a result of the findings of these two sections, and in consideration of the increasing number of ground reports, it was decided, at Air Ministry level, to set up a separate section at ACIU especially organized to cope with the photo interpretations of underground insallations.

The primary mission of B-6 Section was to prepare, at the request of Air Ministry, detailed reports and illustrations for use in the planning of strategic bombing operations. This material was needed in order to determine the relative importance of these installations as targets, for assessing the vulnerability of the various installations, for selecting aiming points, and for briefing purposes. It was clear from the outset that aerial photographs alone could not supply all the data required. Therefore, a combined geological, aerial mapping, and photo interpretation technique was worked out. Large scale contour maps or plans, showing in detail all above ground utilities and facilities in the area around the tunnel entrances, were prepared from rectified aerial photographs controlled by German maps. Where possible, contours were obtained from German maps and if unavailable the aerial cartographer contoured the area from photographs. By means of German geological maps and memoirs, the geologist was able to report the type of rock involved and how it could be expected to react to bombing. He also prepared geological cross sections which indicated the type, structure, and thickness of the rock above the tunnels. The heights of cliffs and of low flying obstacles were determined from photographs by the use of height finders. Perspective drawings were also prepared from photographs and the Industry Section prepared maps showing the electric power distribution system or grid. The Model Section prepared models for two installations. Progress reports, similar to the detailed reports described above, were also prepared.

The secondary mission of B-6 Section was to search photo cover for underground installations reported by ground sources. This was also useful to Air Ministry personnel in evaluating the reliability of the ground sources themselves, not uncommonly prisoners of war. When reporting on the results of cover search, short initial reports were made. If the construction or presence of an underground installation was confirmed, the installation would be monitored until it appeared to be nearly ready to go into production, at which time a detailed report would be prepared, if desired by Air Ministry. B-6 Section did not have sufficient personnel to search all aerial photos received by ACIU. It was the additional responsibility of the other sections, including some that searched all cover, to be on the lookout for underground installations and to report anything suspicious to B-6 Section. In this way many installations were found that were never reported by ground sources. However, several installations were overlooked which could have been recognized by interpreters more experienced in the interpretation of underground installations. The Aircraft Section was of considerable assistance to B-6 Section and located a large number of underground aircraft factories.

Of 227 underground factories now known to have been in production or under construction in Germany and in German occupied countries, approximately 60 were recognized as industrial installations by photo intelligence and were so reported. In addition, where some factories were in production, the finished products were correctly identified. There is reason to believe that the products or function of additional factories that were under construction could also have been identified had those installations gone into production.

The identification of these 60 odd underground factories was made possible by the development of a fairly consistent pattern of procedure by the Germans in the construction and operation of underground factories and the recognition of this characteristic pattern by the photo interpreters at ACIU. This recognition pattern consists of approximately 30 elements, described in this Manual as recognition features or keys to interpretation. The development of this recognition pattern was the result of the application of more or less standard construction and production principles to the field of underground industry. This pattern was more consistent and the elements more numerous for newly excavated hillside tunnel sites, less so for pre-existing sites and was so definite and so consistent that many new sites were recognized and correctly identified as sites for underground factories shortly after excavation had commenced. For plants in pre-existing sites such speedy recognition was seldom possible and many such plants had commenced production before sufficient activity or changes had occurred on the surface to prove the existence of an underground plant. The early discovery and confirmation of the large and fully developed Mittelwerk plant (V-1 and V-2 production) at Niedersachswerfen near Nordhausen greatly facilitated the photo interpretation of German underground factories. This factory, together with four adjoining sites, exhibited many recognition features and served as a basis for comparison in the interpretation of additional factories.

There are a number of reasons why the presence of the remaining 167 German underground factories was not confirmed by photo intelligence during the war. A number of these factories were neither reported by ground sources nor photographed; others were reported by ground sources but could not be located in gazetteers; some were photographed but the photography was poor or not new enough or they were overlooked for other reasons; and some, that were located either with or without the guidance of ground reports, could not be definitely confirmed because of the lack of sufficient evidence. Most of the latter, as well as many that were overlooked, were in old mines and storage tunnels, and had started limited production or were still being set up. The presence of these factories was difficult to confirm by means of aerial photographs because the sites selected often were already provided with utilities and transportation facilities previously built for normal commercial use. Therefore, apart from an increase in road and rail traffic, there was nothing in many cases to indicate that these sites were being converted to a new use. However, as many of these factories were approaching full scale production there arose a need for supplementary utilities and facilities. In some cases this had already led to the construction of new electric power lines, water pipe lines, housing, and so forth, and the open-air storage of materials related thereto. In the case of vertical-shaft salt mines the tremendous amount of floor space provided by these mines could not be fully exploited until additional shafts were excavated. Many German salt mines have from 1,000,000 to 4,000,000 square feet of floor space but are provided with only one or two shafts. These are sufficient for mining operations but not for large scale manufacturing purposes. Unless additional shafts are excavated only about 350,000 square feet of floor space can be utilized for manufacturing purposes because the shafts act as a bottleneck in moving workers and materials in and out of the mines. By the end of the war additional shafts, both vertical and inclined, were already under construction at several German salt mines. Thus it is likely that many additional underground factories would have been located and correctly identified by photo intelligence had the war continued. In other words, a certain amount of time was necessary for these factories to develop the features characteristic of the German underground factory recognition pattern.

As it was, about the only way that more of these installations could have been found would have been by the expenditure of more effort in this field, i.e., more widespread photographic coverage of Germany and German occupied countries, more frequent photo reconnaissance of suspected underground sites, and more photo interpreters assigned to this specific field.

However, there were a number of small machine shops in old beer storage tunnels and other pre-existing sites that in all likelihood could have avoided detection indefinitely. The entrances to these sites in many cases were concealed by old buildings. And the existing utilities and facilities were sufficient to satisfy requirements with little or no modification. However, it should be extremely difficult to construct and operate in time of war an underground factory of 1,000,000 or more square feet of floor space without detection by photo intelligence, provided good photo cover is available, unless the camouflage of the installation is supervised by a photo interpreter experienced in the photo interpretation of underground installations. This leads to the obvious conclusion that the tunnels, surface utilities, and facilities should be constructed during peace time in order to decrease the chance of detection during wartime. In many cases this could be done in conjunction with normal commercial mining with a minimum of expense and publicity.

When the U. S. Army Air Force began the strategic bombing attacks on the Japanese aircraft industry in the fall of 1944 a considerable part of the Japanese aircraft production was concentrated in and around Tokyo, Nagoya, and Osaka. Prior to the initial attacks there had been no dispersal of the industry of any consequence, either above ground or underground. Dispersal had actually been planned early in 1944, before the industry was attacked, but because of the constant pressure for production the government withheld permission to disperse until production could be maintained or expanded in the process. Some companies, however, in anticipation of a government order to disperse, began to dismantle their plants early in the fall of 1944.

Following the attacks of November and December a panic dispersal of the aircraft industry began, without government direction or control.

Many machine tools, jigs, dies, workers and materials were scattered far and wide to numerous towns and villages. Machine shops were set up in school buildings, warehouses, textile mills, old tunnels and mines, and even in shrines. Many of the above-ground dispersals were later bombed in area raids. In February 1945 the government assumed control of the dispersal program and ordered the general underground, semi-underground, and surface dispersal of industry. The aircraft industry was given first priority on transportation, construction, finance and food. By April and May the dispersal of industry was taking place on a fairly large scale. The plan called for 993 dispersal sites including 172 underground sites. Of the latter, 120 were to produce aircraft and aircraft equipment. Nevertheless, the program was started too late to change the course of the war and had been underway less than six months when the war ended.

By the end of the war 32 underground aircraft plants had reached some stage of production and 68 additional ones were under construction. These 100 plants had a planned floor space of 12,540,000 square feet of which 7,230,000 square feet had been either completed or excavated. Approximately 73 of the sites were newly excavated tunnel sites. The remainder were abandoned mines, railway tunnels, highway tunnels, and streetcar tunnels. Semiunderground buildings and bunkers also were constructed. By the summer of 1945 about 55 percent of the work required for the underground program had been completed; 11,000 machine tools had been moved into the underground plants and 35,000-40,000 workers were employed underground. As for production, very little was actually achieved. Many of the tools were still in the process of alignment and testing and were not ready for use. Also, considerable work remained to be done on transportation facilities and utilities. The installation of ventilation ducting and equipment was still largely in the planning stage. At least another six months would have been required before all plants could have gotten into production and a longer period of time for 100 percent operation.

Although the Japanese had some general knowledge of German underground installations, they stated that any similarity to the German program was due to the fact that similar events forced both countries to resort to the only apparent possible solution. They stated that strategic bombing forced them to take the only course open to them, to move the factories where they would be hard to find and difficult to bomb. In this, they were largely successful.

The photo interpretation for the strategic bombing of Japan was done largely in Washington, D. C., by a combined unit under the Office of The Assistant Chief of Air Staff, Intelligence, Headquarters, U. S. Army Air Forces. There were also interpretation units at Guam and at Pearl Harbor. The unit in Washington was composed of Air Force, Navy, and British personnel. Some ground information was received regarding the Japanese underground dispersal program but specific data on the location of dispersal sites was meager. Photo interpreters were not alerted to look for underground installations. In addition, most of the photographic coverage was of cities and did not extend out into the country far enough to cover even one third of the existing underground plants. In areas of adequate photography groups of tunnels that were being excavated for the purpose of housing factories were identified as "areas of tunnel activity," but their true significance was not understood. Some underground plants were regarded as storage depots. No requests were made of photo interpreters for specific data on underground activity, hence in an already full schedule little attention was given to this work. Only three or four Japanese underground aircraft plants were reported by photo intelligence during the war and of those described in published reports the true function of none was recognized. This is not too surprising when it is remembered that very little if any more was known about the German underground program six months after it was started than was known about the Japanese program at the end of the war in the Pacific.

Many of the newly excavated Japanese sites exhibited a recognition pattern strikingly similar to new German sites at the same stage of construction. The Japanese sites differed from the German sites in certain respects mainly in that utilities and transportation facilities were poorly developed. This was a temporary difference, however, rather than a fundamental difference. In other respects there was great similarity; in the arrangement of tunnel entrances, in the disposal of spoil, in the storage of materials near the entrances, in the location of housing and contractors buildings, and so forth. There was even greater similarity among the different Japanese sites themselves which suggests the development of a recognition pattern on a parallel with the German pattern. If the lessons learned at ACIU regarding the interpretation of German underground installations had been applied to the interpretation of the Japanese underground plants, and if a concentrated effort had been made to locate and identify such plants, greater results could have been obtained. This conclusion is based upon the assumption that rapid and efficient channeling of ground information to the interpreter would have occurred and that conditions would have permitted the photo reconnaissance of underground sites at the request of the interpreter, as was possible at ACIU.

POST WAR TREND

When the full magnitude and strategic implications of the German and Japanese underground programs were completely unveiled at the end of World War II there arose considerable speculation as to the future application and use of this inactive defense measure. It was generally agreed that hostilities in both the European and Pacific theaters of operations would have been at least prolonged, with a resultant greater loss of Allied lives, if the Germans and Japanese had completed their underground programs before hostilities commenced, or at least early in the war.

In view of the difficulty of locating underground installations, in consideration of the performance data on large semiarmor piercing bombs, and from the negligible effects of the atomic bomb on underground air raid shelters at Nagasaki and Hiroshima, it became clear that the placing of strategic installations underground offered considerable advantages with regard to concealment from aerial observation and protection from aerial bombardment. Interest in underground installations was heightened by the fact that long range bomb carriers had now brought within bombing range many targets that heretofore were relatively safe because of distance from a potential enemy. Many analysts accepted the principle that certain vital installations should not only be protected by being placed underground but should be built and put into operation during peacetime. The economic feasibility of such an undertaking is supported by a study of the cost factors involved for installations built and operated in Germany and in Sweden, and for installations proposed in the United States.

The construction and operation of underground installations did not stop with the end of World War II. Since the war the use of this defense measure has not only continued but also has become world wide in scope. Active underground projects have been reported to be either in operation, under construction, or in the planning stage in the following countries: Albania, Argentina, Austria, Czechoslovakia, Egypt, Finland, Greece, Norway, Poland, Sweden, Soviet Zone of Germany, Soviet Union, Turkey, and Yugoslavia.

The majority of the installations reported are alleged to be in the Soviet Union and in Soviet satellite countries. The installations reported are of various classes, that is, armament factories, submarine pens, maintenance and storage facilities, airfield hangars, and military barracks. Although many of these underground sites are described as tunnels in solid rock, others are reported to be semiunderground, for example, buried and earth mounded.

Several German underground factories in the Soviet Zone of Germany were operated under Soviet supervision for approximately a year after the end of World War II. This gave Soviet engineers an opportunity to study the construction technique employed by the Germans as well as to recognize, segregate, and solve problems incident to the underground manufacture of aircraft, related equipment, and other munitions. Nearly all of the larger German underground factories, as well as many of the German engineers who built and operated them, are in the Soviet Zone. Thus the Soviets have had an unparalleled opportunity to benefit from the German experience.

Although the evaluation and volume of ground reports concerning underground installations in the Soviet sphere are not sufficient at present to prove conclusively that the Soviets have adopted a really large scale underground program for the manufacture of armaments, the lack of a large number of reports does not necessarily mean that the installations reported constitute the entire Soviet underground program. In regard to underground maintenance, storage facilities, and airfield hangars, it can be stated that a program is being strongly implemented. From the information available it would appear fairly certain that the Soviets have learned a lesson from World War II to the effect that active defense weapons cannot as yet provide complete protection against attacking bomb carriers. Furthermore, in view of the range of modern bombers and the destruction that a single bomb carrier now can inflict the Soviets appear to have accepted the principle that cerain vital installations should not only be protected by being placed underground but should be built and put into operation during peacetime.

GROUND INFORMATION

Ground information regarding underground installations is of great importance to the photo interpreter not only in locating such installations but in assessing their vulnerability after they are located. Photo intelligence and ground intelligence are complementary and of mutual assistance to each other. The production of a maximum amount of useful intelligence on underground installations requires considerable research and the collection, collation and use of information derived from a great variety of sources. If information from ground sources is withheld from the interpreter he will be considerably handicapped not only in locating underground installations but in the interpretation of those that he does locate. Conversely, if an analyst is limited in his work to current ground reports and to photo interpretation reports prepared without benefit of ground information, the resultant intelligence will be less useful, not as complete and of poorer quality than would have been possible if all available ground information had been made available to the interpreter in the first place. An attempt to produce "pure" photo interpretation reports on underground installations, that is, without a thorough study of available ground information, would be not only unrealistic but would be a failure to exploit the full capabilities of photo intelligence.

The realization of the full significance of activity seen on photographs is in large part determined by previous knowledge based on reliable ground information. For example: in the search for an underground factory reported in a certain area during the war it would have been of tremendous help to the interpreter if he had known that a large mine was present in the area. As it was, activity connected with the installation of a factory in the mine was tentatively interpreted as preliminary preparations for the excavation of tunnels, which in fact, but unknown to the interpreter, already existed. The entrance to the old tunnels had become overgrown with trees and bushes and could not be seen on photographs. Later on however, research uncovered a geological map and a geological bulletin which revealed the fact that a large mine suitable for housing a factory was present at the place under study. This fact altered the significance of the activity seen and was of vital importance in the interpretation of this installation. In other words, the discovery and confirmation of this particular underground factory was based on the fitting together of fragments of information from three entirely separate sources. Each fragment taken separately was inconclusive but when put together they formed a fairly complete picture. The geological bulletin and map established the fact that a suitable underground site existed; the ground report indicated that this site was being converted to a new use; and aerial photographs confirmed the presence of activity at this site, activity which fitted the German underground industry recognition pattern. The detailed photo interpretation report that was prepared on this site presented these fragments of information separately and indicated their respective sources but then proceeded to show how they fitted together. In this way it was clear to the reader how much of the information presented was from ground sources and how much was derived from aerial photographs.

During World War II the compilation of data on German underground installations was done by photo interpreters at the Allied Central Interpretation Unit. Current ground reports were routed automatically to the interpreters and were quite useful in directing attention to specific sites. Large scale contoured maps, town plans, and aerial photographs were available on the premises as were facilities for the reproduction of the final reports. Additional aerial photos could be obtained by request. Considerable research and travel were done in order to locate copies of German geological maps and bulletins, ground photographs, and data on the location and status of caves and mines. Most of the information that was found had been collected before the war by individuals and by universities and was widely scattered.

Based on past experience and in view of the trend toward the utilization of underground installations by the Soviets, an effort should be made to collect all pertinent information available on underground installations and sites for potential installations in the Soviet Union, in Soviet satellite countries, and in countries which conceivably could become Soviet satellites. This material should include, wherever possible, aerial photographs, ground photographs, geological maps, geological bulletins and reports, large scale contoured maps, town plans, literature, tunnel plans and cross sections of mines, caves, storage tunnels, railway tunnels, highway tunnels, deep cellars, and so forth, and should include the exact location, status, thickness of overburden and size of each site.

INTERPRETATION KEYS

In view of the fact that aerial photographs show only above ground features, the photo interpretation of an underground installation necessarily involves a detailed interpretation of all above ground facilities, utilities, and activity in the area surrounding the suspected site.

Many underground installations are characterized by extensive above ground features, extensive both in number and in the area that they cover. These characteristic above ground features are useful to the photo interpreter as recognition features or interpretation keys. Collectively, they form a distinctive recognition pattern quite unlike that of any other type of installation. The more common keys that make up this pattern and that either separately or collectively may indicate the construction or presence of an underground installation are as follows:

a. Test borings, both horizontal and vertical.
b. Tunnel entrances or clearance of trees at sites of excavation.
c. Spoil heap or flare (waste dump).
d. Shaft house or head frame to vertical shaft mine.
e. New entrance shaft, vertical or inclined.
f. Narrow gauge construction railway.
g. Standard gauge railway spur.
h. New roads and paths.
i. Excavating equipment, trucks, and so forth.
j. Buildings.
k. Barracks.
l. Open-air storage.
m. Ventilation shafts.
n. Smoke stacks or chimneys protruding from the ground.
o. Power lines and transformer stations.
p. Water wells, pipe lines, pump houses, and reservoirs.
q. Sewage plants and pipe lines.
r. Test facilities and associated airfields.
s. Finished products or recognizable means of conveyance.
t. Protective wire fences.
u. Guard towers.
v. Protective construction at tunnel entrance or over entrance to vertical shaft.
w. Camouflage nets, paint, and so forth.
x. Cranes and gantry cranes near tunnel entrances.
y. Sand and gravel pits.
z. Miscellaneous activity disassociated with normal commercial mining.

The recognition pattern formed by the above-listed interpretation keys is normally more fully developed at the larger and older installations. Also, it is more readily apparent at new hillside tunnel sites during the excavation and construction period than it is at pre-existing sites already provided with utilities and facilities previously built for normal commercial use. The installation of small industrial plants in favorable pre-existing sites may require the construction of only a few or no additional above ground facilities and utilities and thus may avoid detection. However, the installation of a large factory in an average pre-existing site normally would necessitate the construction of sufficient above ground facilities and utilities to reveal its presence.

The following types of sites were utilized for housing industrial plants during World War II.

a. New interconnected tunnels in the side of a hill.
b. Hillside mine tunnels, iron, limestone, and so forth.
c. Vertical mine shafts, salt, potash, and so forth.
d. Railway tunnels.
e. Highway tunnels.
f. Beer storage tunnels.
g. Mushroom culture tunnels.
h. Hydro-electric plant water tunnels.
i. Natural caves, limestone, gypsum, and so forth.
j. Deep cellars and basements.
k. Old fortification tunnels.
l. Semiunderground reinforced concrete bunkers, (both flat and arch-shaped roofs).

Test borings, both vertical and horizontal, were made at a number of German sites where the excavation of new tunnels was contemplated. Portable rotary diamond core rigs were used. Although a fairly good idea of the geology can be obtained from surface outcrops it is normally advisable to core drill in order to determine the exact thickness of the beds of rock, their subsurface structure, their degree of consolidation, and the depth of weathering. Local variations which cannot be determined at the surface can cause serious difficulties if not discovered beforehand. At two German sites it was necessary to change the plan of tunnel excavation because inadequate exploration of the sites failed to reveal, in one case, local masses of unconsolidated rock, and in the other, large joints or cracks aligned in the same direction as the tunnels. Such changes in the plan of excavation tend to delay completion of the project, increase the cost of construction, and might adversely affect the production efficiency of the plant to be installed.

Core drilling of new underground sites, however, was not widely done during World War II because of a shortage of equipment and because of the hasty and simultaneous construction of hundreds of projects. It was rarely employed where pre-existing tunnels were to be extended inasmuch as the underground nature of the rock was already revealed.

The actual bore holes themselves, of course, cannot be seen on aerial photographs but other signs of core drilling can be seen. For horizontal core drilling (Figs. 1, 2, and 3), a row of small evenly spaced benches or notches, with their resultant spoil heaps, can be seen cut into the side of the hill. These little benches were dug out in order to provide a level platform for the drill and a foothold for the workmen, as well as to provide a stable vertical face to drill into. These little excavations with their attendant spoil heaps may be distinguished from tunnel excavations by their rather inaccessible location above the valley floor, by their small size, and by the fact that once they attain their maximum size they never grow any larger. They are also closer together than is normal for entrance tunnels.

Evidence of the drilling of vertical test holes not only differs in appearance from that for horizontal drilling but is less permanent in nature and may be present or readily apparent for only a few weeks. The little benches and spoil heaps typical of horizontal borings would be absent. The cores obtained are likely to be carried away for study elsewhere but some spoil and ground scarring may be expected. Core rigs are difficult to see in woods but should be identifiable on large scale cover of treeless ground or of thin deciduous woods in winter. Other evidence will be the vehicles for transporting the rig and the drill pipe, accompanied by the resultant tracks and ground scarring. Also, there could be evidence of the supply of water or "mud" needed for cooling the bit during the drilling operations. At one site the Germans used a surface pipeline and an electric pump for transporting the water to a tank or cistern located on top of the hill being explored. The water was distributed to the various drill holes by a network of additional pipelines. However, water could be delivered by water truck as is done by American geophysical crews in the drilling of shot-test holes for seismographic surveys in the search for new oil fields. Also, the use of small "slush pits" instead of tanks or cisterns should be anticipated.

The photographic evidence of horizontal and vertical test boring should be susceptible to interpretation on good cover of large scale, even among trees where they are not too thick, or in the case of deciduous trees, in winter. The detection of such evidence, used with a knowledge of the local terrain and geology, might well serve to confirm the suspicion that an underground industrial area was being planned. It would be among the earliest evidence to appear and the vertical borings would indicate the general area beneath which the excavation of tunnels was contemplated.

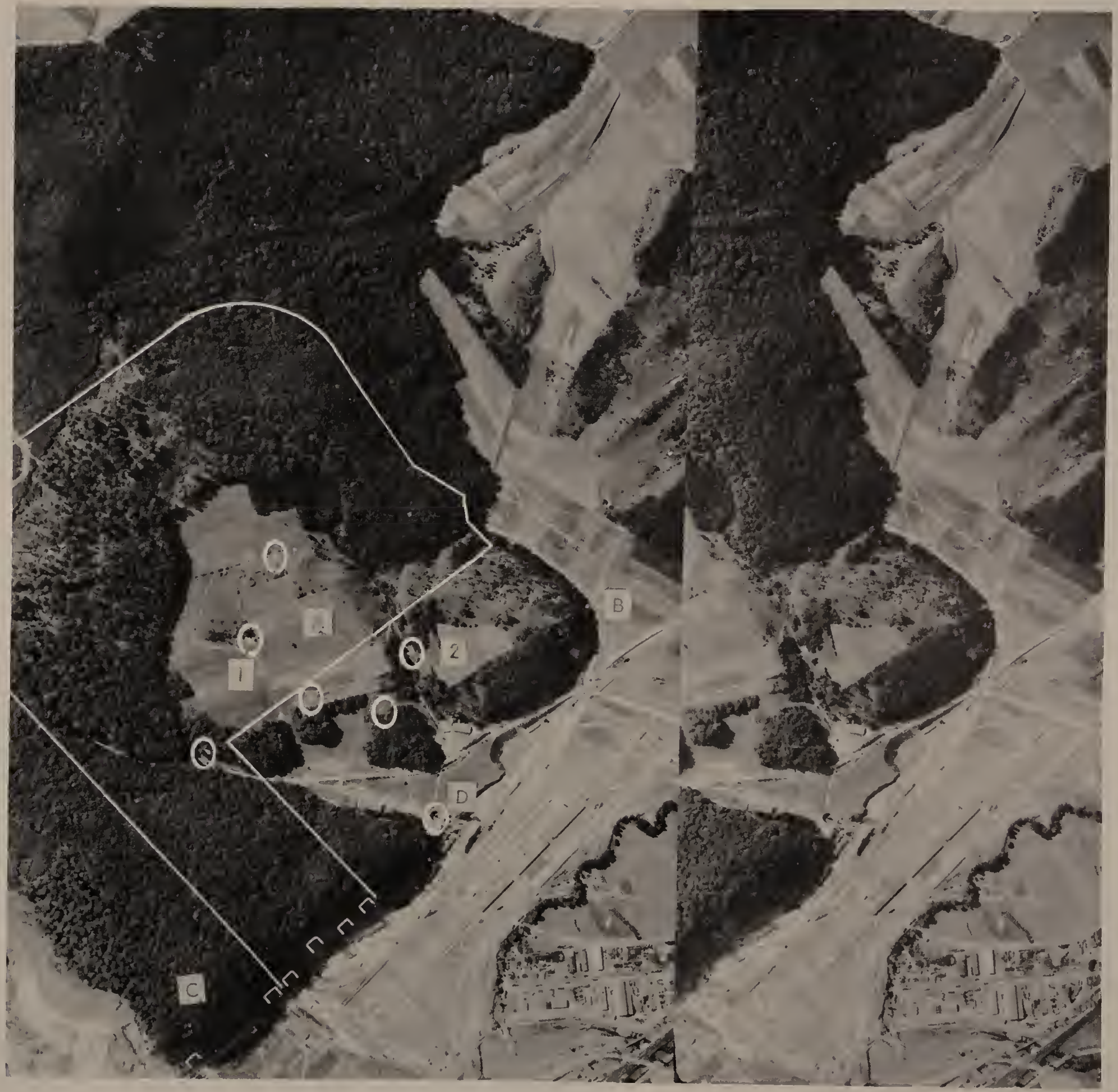

FIGURE 1. Vertical and horizontal test borings at the northwest end of the Kohnstein, a hill near Nordhausen, Soviet Zone, Germany. The sites of the vertical test borings (A) are indicated by areas of ground disturbance (white areas) connected by vehicular tracks which cross cultivated fields. Some of the bore hole sites are more prominent than others. This might indicate different stages in the progress of the work although no drilling rigs can be made out with any degree of certainty at any of the sites. No ground check report on these particular bore holes is available but the ones indicated correspond in location to those shown on a captured German plan. It is not known how water for cooling the drill bits was supplied at this place. It may possibly have been hauled in by trucks in view of the well beaten tracks and the presence of what appear to be small circular "slush pits" at bore holes 1 and 2. The horizontal borings (B) can hardly be made out on this particular cover and can be seen more clearly in Fig. 2. The appearance of test borings in this area was one of the first clues that this part of the hill was being considered for exploitation as a site for an underground installation. This was Project Zinstein, a Junkers jet aircraft engine factory. An outline of the area selected for exploitation is shown at right. Four tunnels were under construction when the war ended. These are adjacent to the Junkers Nordwerk aircraft engine factory (C). A steam shovel is shown at D.

Cover: Prints 3019–3020 of Sortie 106G/2413, dated 14 September 1944. Scale 1:9,900.

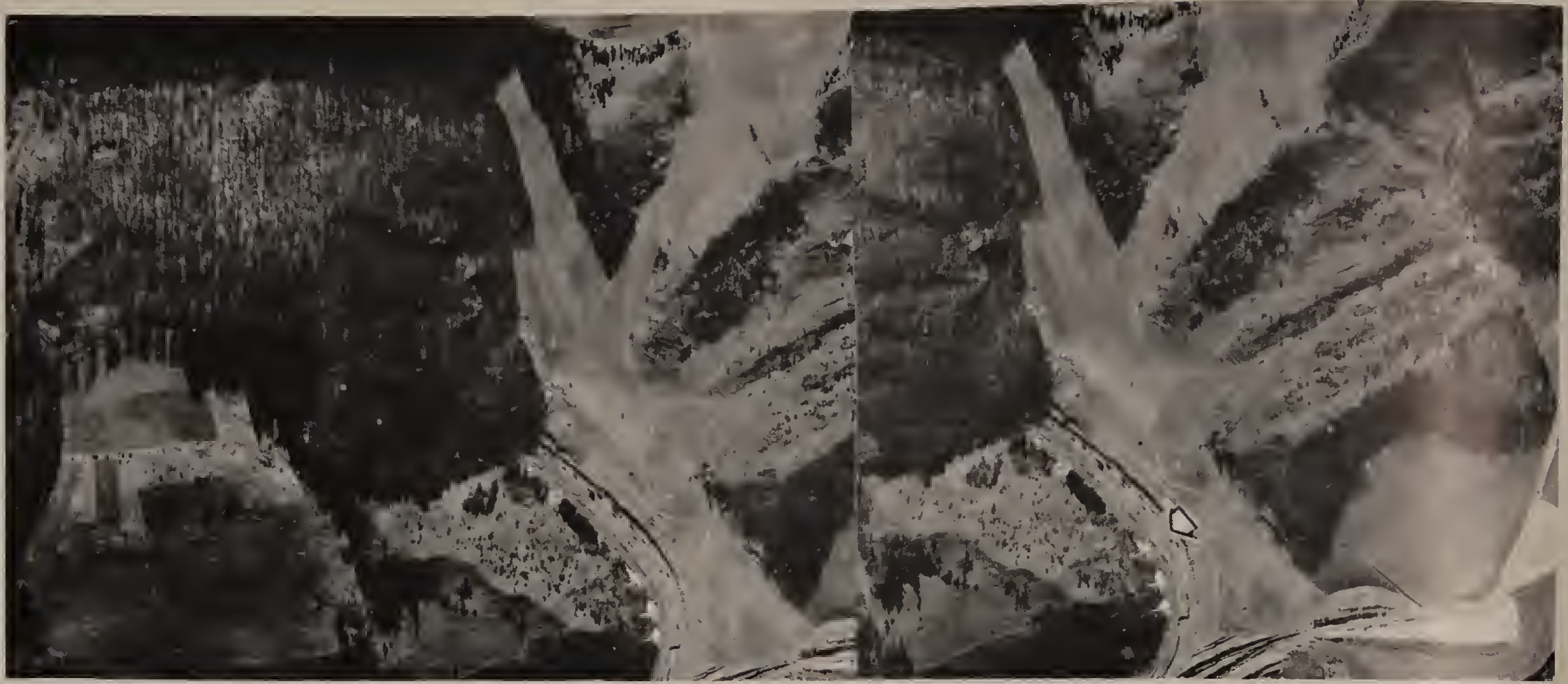

FIGURE 2. Part of the same area shown in Fig. 1 but about six months later. Note that time has now nearly erased all trace of the vertical bore hole sites but that the horizontal bore hole sites show up quite clearly owing to the absence of shadow and foliage. The long arc-shaped cut in front of the horizontal bore holes leads to the site of a proposed entrance to a transportation tunnel. Work on this tunnel had barely started when the above photos were taken.

Cover: Prints 4201-4202 of Sortie 106G/4779, dated 14 March 1945. Scale: 1:9,000.

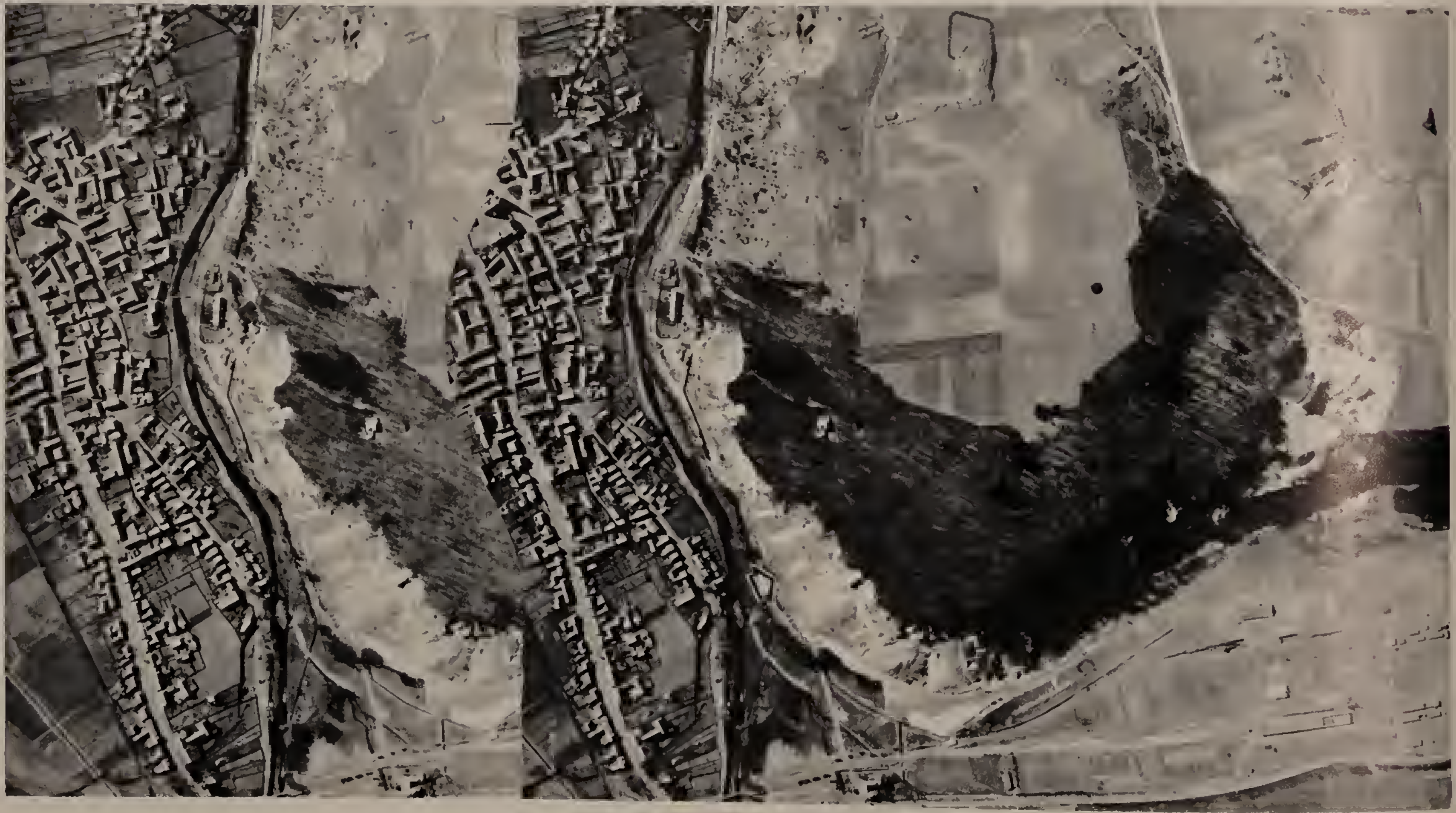

FIGURE 3. Horizontal test borings in the east end of the Muhlberg, a hill at Niedersachswerfen near Naudhausen, Soviet Zone, Germany. Note that these bore holes are located about half way up the side of the hill and are connected by a foothpath. This hill was selected as a site for a large new underground factory, allegedly reserved for a Junkers jet aircraft engine factory. The construction and excavation work had just started when the war ended and only about 50 feet of one tunnel had been excavated. Photographs taken on 12 September 1944 show that the test borings were present at that time. Their appearance was the first indication that this hill was being considered as a site for an underground installation.

Cover: Prints 4116-4117 of Sortie 106G/5105, dated 25 March 1945, Scale: 1:8,000.

In view of the fact that all underground installations must have some means of entry, the identification of such openings is one of the more positive photo interpretation keys to the presence of such installations. In addition, an accurate determination of the location and elevation of the entrances is essential in order to assess the vulnerability of the installations to aerial bombardment. Nevertheless, as important as the identifcation of the entrances may be, it is possible in many cases to confirm the presence of an underground installation even though the entrances may be concealed by shadows, trees, camouflage, or buildings. Also, the external appearance of the entrances themselves rarely reveals any more about the specific function of the installation than do the entrances to surface buildings.

The entrances to underground installations may be grouped into two general classes: (a) approximately horizontal entry tunnels in the side of a hill, mountain, or rising ground; and (b) vertical shafts which give access to horizontal tunnels underground. The latter will be described in a subsequent section of this Manual.

The excavation of a horizontal entry tunnel into the side of a steep hill, mountain, or rising ground necessitates, at many localities, the excavation of an open cut leading to the entrance to the tunnel. These open cuts tend to decrease in length with an increase in the steepness of the slope of the ground, until eliminated altogether, in the case of tunnels excavated in a vertical cliff. In the latter case the entry open cut is not only absent but the tunnels themselves are difficult or impossible to see on vertical photographs. Entry open cuts have a distinctive angular wedge-shape which is easy to recognize. In fact, many entry tunnels can be located, not by the fact that they can be seen themselves, but by the characteristic open cut which leads to them. The alignment of the cut also indicates the alignment of the initial section of the entry tunnel underground.

Many tunnels driven into a wooded hillside cannot be seen on photographs taken at certain times of the day or year because of shadow from the trees or from the hill. However, their presence can be deduced at some sites by the presence of a clearing in the woods at the site of each open cut leading to the tunnel entrances.

Where tunnel entrances are effectively concealed by shadow, trees, camouflage netting, or even buildings, it is sometimes possible to deduce their presence by roads, paths, or railways which approach the hillside at an angle which makes further progress in that direction impossible unless such progress is underground. Such evidence, of course, must be evaluated in relation to other evidence present.

Tunnels in the side of an open face quarry normally are not sufficient evidence in themselves to prove the existence of an underground industrial or storage installation. It is not uncommon at some stone quarries to change the method of extracting the rock from open face quarrying to underground mining. This is necessitated for economic reasons at some quarries because of the increasing thickness of the nonsaleable overburden (soil and weathered rock) which is encountered as the quarry face is gradually pushed back. However, many pre-existing tunnels in quarries provide suitable underground space for exploitation and many quarries without tunnels are excellent sites for the excavation of new tunnels for underground installations. The determination of whether or not the tunnels in a quarry are being excavated or used for an underground installation will depend upon a consideration of all the associated features. It should be pointed out that the presence of narrow gauge railways leading direct to a quarry face (where tunnels cannot be seen) is not necessarily proof of the existence of tunnels. The use of such railways in open face quarrying is fairly common practice in many countries.

The presence of tunnels at many newly excavated sites, or at sites where pre-existing tunnels are being extended, is frequently indicated by the presence of spoil heaps formed by the rock that was removed from the tunnels during their excavation. Where spoil is removed from the tunnels by narrow gauge railways the spoil heaps or flares tend to develop a triangular shape with the apex of the flare pointing in the general direction from which the spoil has come. This is of assistance in locating the tunnel entrances. The interpretation of spoil will be described more fully in a subsequent section of this Manual.

Unlike normal commercial mining, many newly excavated underground installations have a large number of tunnel entrances, as many as 45 in one case. The main purpose of having such a large number of entrances is to make it possible to excavate simultaneously at a maximum number of points and thereby increase the rate of progress of the tunneling operations. A fairly consistent and distinctive feature of these multiple entrances is that they are spaced at regular intervals. This is an external reflection of the internal lay-out or arrangement of the tunnels which commonly follow a fairly uniform interconnected grid pattern. The entrance tunnels normally are used for transportation purposes and the connecting or cross tunnels for housing the installation proper. As might be expected, there are local variations to this arrangement.

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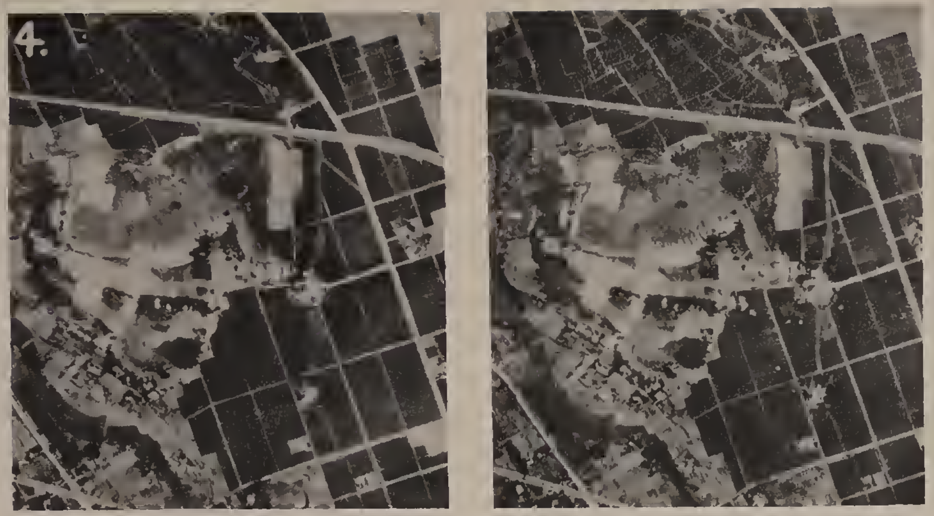


FIGURE 4. Excavation, during World War II, of an underground site for an airframe parts factory, located near Shirakawa, Japan. Note the row of open cuts in the central part of the photograph. Each cut leads to the entrance to a tunnel. Additional entrance tunnels also are under construction in the opposite side of the hill and in the adjacent hill shown in the lower half of the photograph. These are indicated by spoil heaps and clearings in the woods.

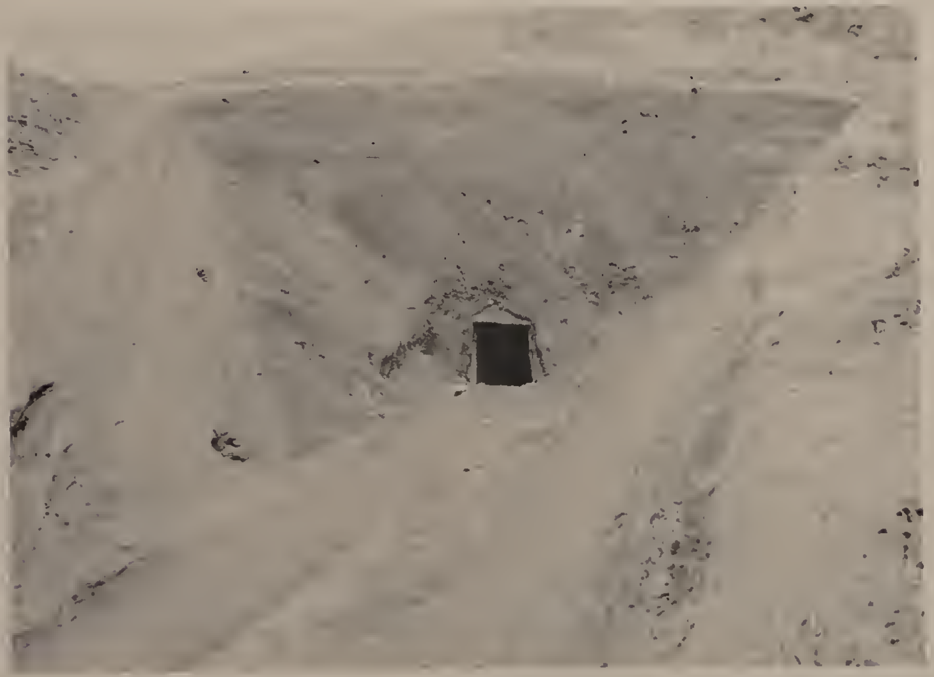


FIGURE 5. Typical open cut leading to the entrance to a tunnel. Bomb storage tunnel on Saishu Island, Japan. Signal Corps photo No. WPA–45–61226, dated 10 April 1945.

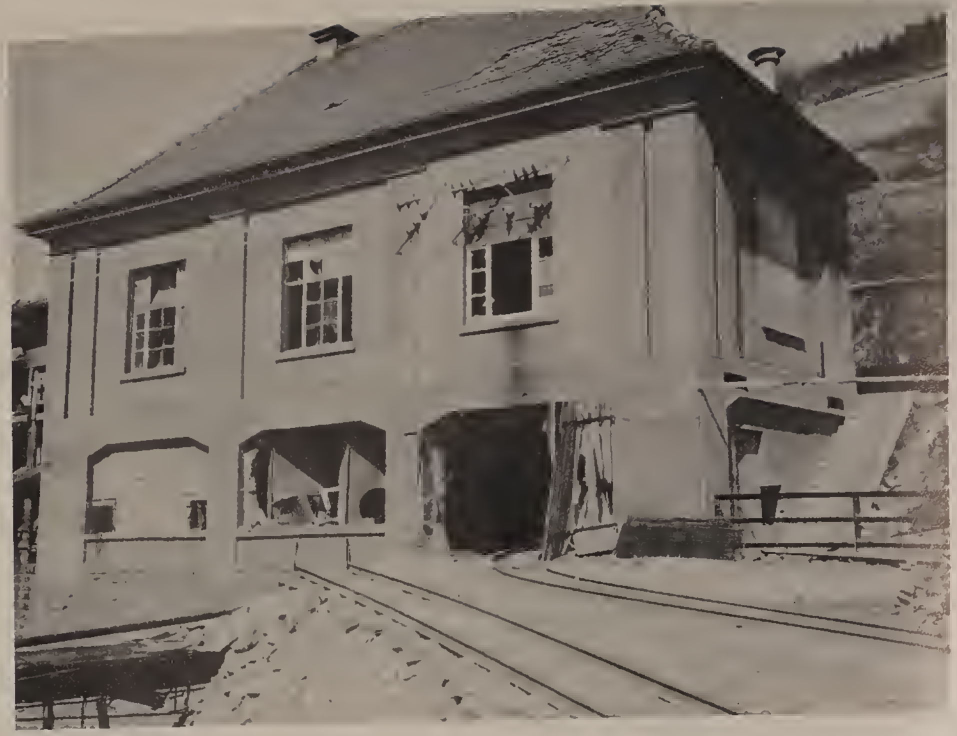


FIGURE 6. Entrance to underground ball and roller bearing factory installed in a gypsum mine at Neckarzimmern, U. S. Zone, Germany. Signal Corps photo No. ETO–HG–45–25442, dated 11 April 1945.

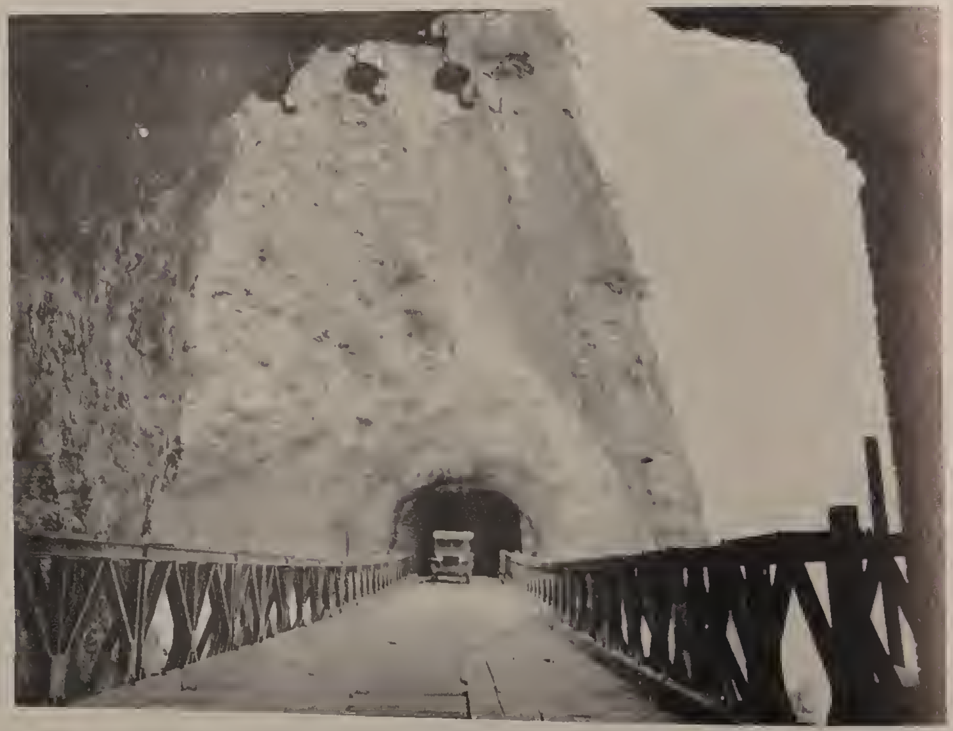


FIGURE 7. Entrances to a Fiat aircraft engine factory installed in a series of road tunnels along Lake Garda, south of Riva, Italy. Signal Corps photo No. 5/MM–45–11251, dated 28 June 1945.

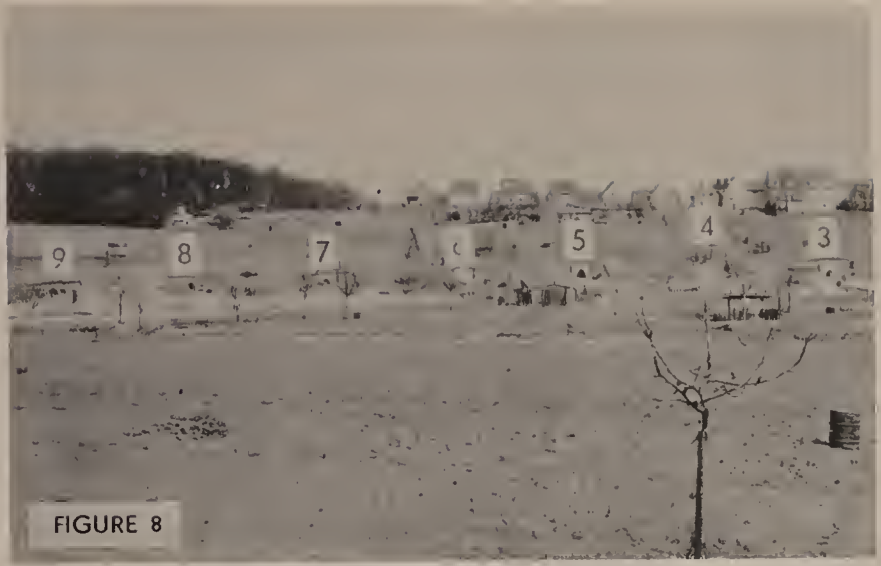


FIGURE 8

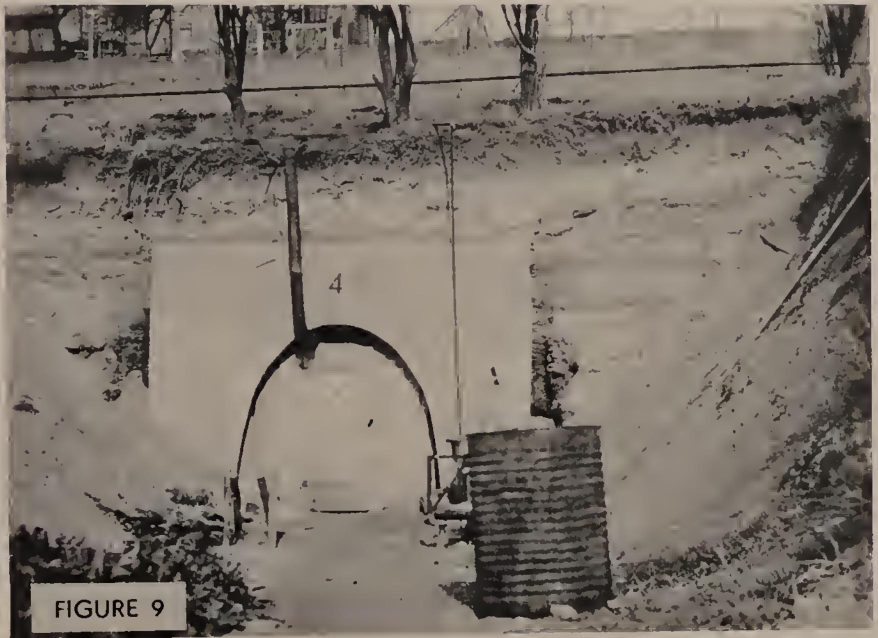


FIGURE 9

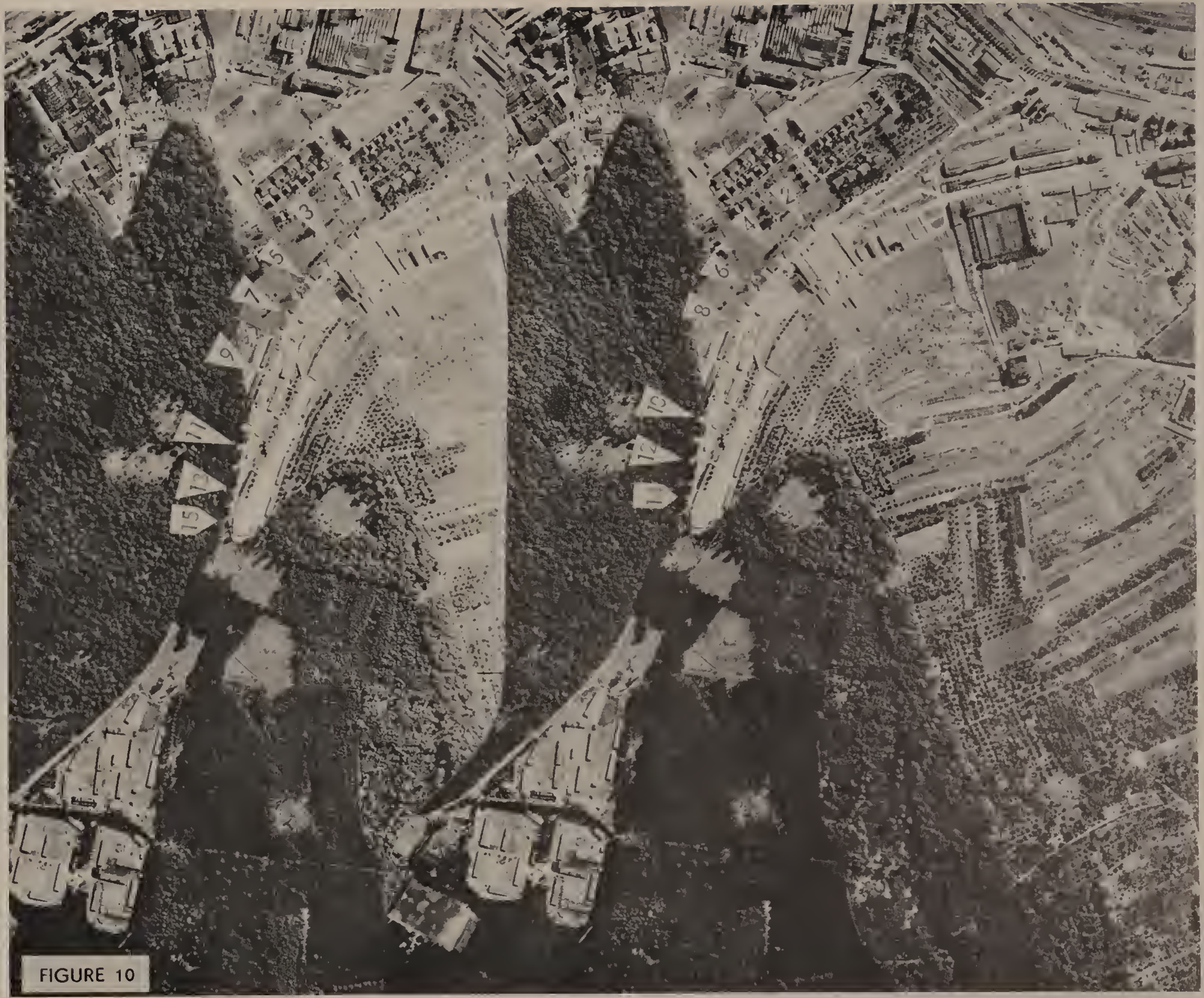


FIGURE 10

FIGURES 8, 9, and 10. Underground site for part of the Robert Bosch electrical works, located at Feuerbach, near Stuttgart, U. S. Zone, Germany. These tunnels were excavated originally for use as an air raid shelter but later were taken over and extended for manufacturing purposes. The total floor space available underground amounted to 76,500 sq. ft. The construction work was not completed when the war ended. Note the appearance of the entry open cuts, the clearings in the woods for tunnels 11–15, the fairly uniform spacing of the tunnels, and the three spoil heaps. This installation was described as a possible underground factory in ACIU Photo Interpretation Report No. U. 29, dated 17 February 1945. Cover: Prints 4135–4136 of Sortie 106G/2812, dated 12 September 1944. Scale: 1/9,600. Ground photographs by USAFE field team, March 1946.

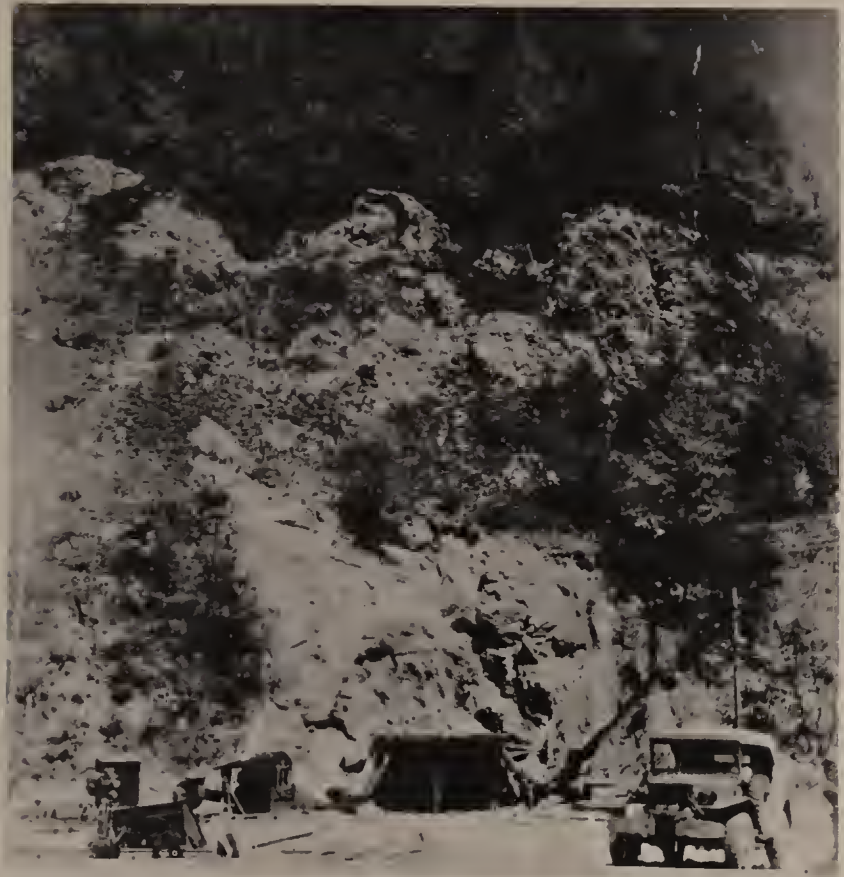


FIGURE 11. Entrance A to the Henschel underground guided missile factory at Woffleben, Soviet Zone, Germany, also shown in Fig. 12. The above photo shows the weathered condition of the surface rock and the timbering needed to support the tunnels during their passage through an external zone of gypsum. Once through this zone the tunnels enter unweathered anhydrite and open up to full size, in this case, 37 feet wide by 37 feet high. No lining or reinforcement was needed for the tunnels in the anhydrite. It is alleged that the cross galleries were to have had three floors. Photo by CIOS Team 163, June 1945.

LEGEND
for Fig. 12

▨ Tunnels occupied
■ Tunnels excavated
☐ Tunnels planned

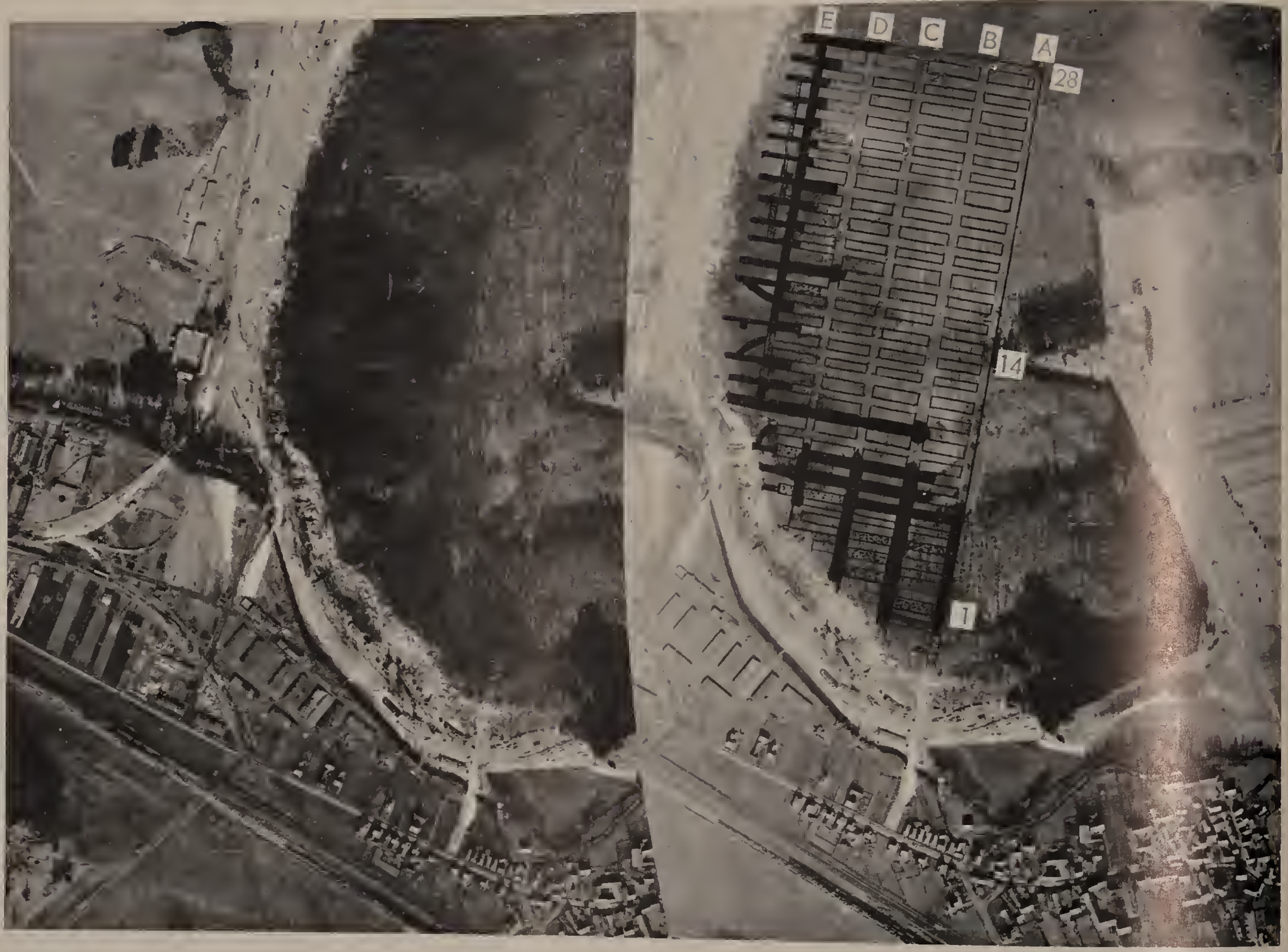


FIGURE 12. Stereogram of Henschel underground guided missile factory at Woffleben, Soviet Zone, Germany. The tunnels at this site were planned from the beginning for a factory with 1,317,000 sq. ft. on the ground floor. If all tunnels had been completed and three floors installed in the cross galleries this installation would have had a total floor space of 2,863,000 sq. ft. Excavation had provided 275,000 sq. ft. by the end of the war. Note the large scale use of narrow gauge railway for the removal of rock (90 cm. for entrances E, 6–28 and 60 cm. for entrances A, B, and C). Note also how effective shadow can conceal entrances and conversely how narrow gauge railway trackage gives them away. The canopy-like structures extending out from some of the entrances are constructed of camouflage netting suspended on a framework of wood and garnished with natural evergreens. However, this camouflage was not maintained and was not present at all entrances. The main spoil heap or waste dump is not shown in this stereogram although considerable spoil has been spread out in the valley opposite entrances 10–28. Limited experimental production had commenced at this site. This installation was described and reported as an underground factory under construction in ACIU Photo Interpretation Reports U.2, dated 23 November 1944 and U.45, dated 30 March 1945.

Cover: Prints 3200–3201 of Sortie 106G/4779, dated 14 March 1945. Scale: 1/9,000.

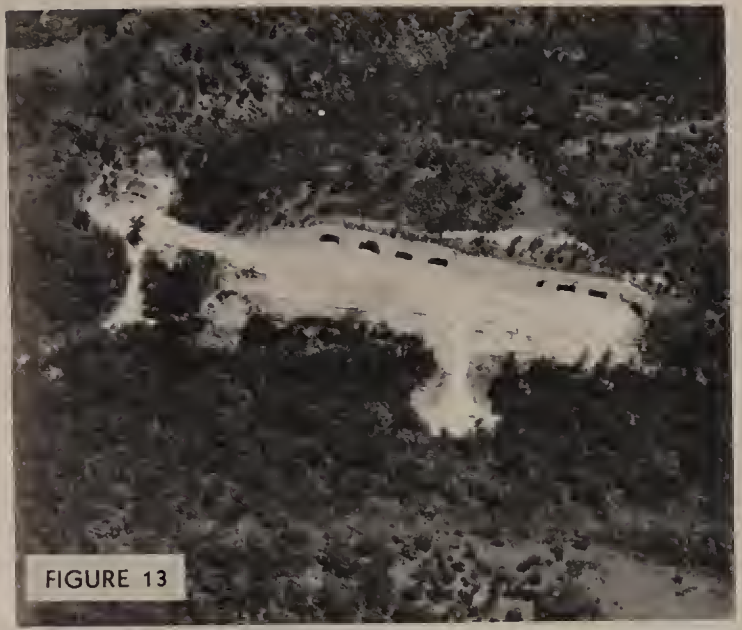


FIGURE 13

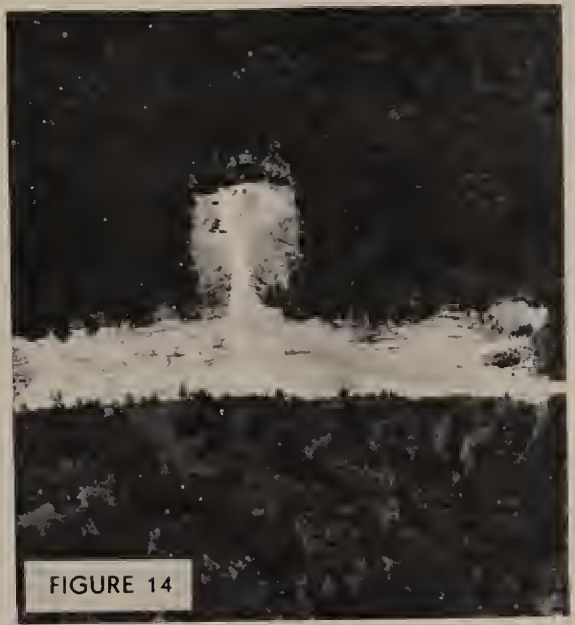


FIGURE 14

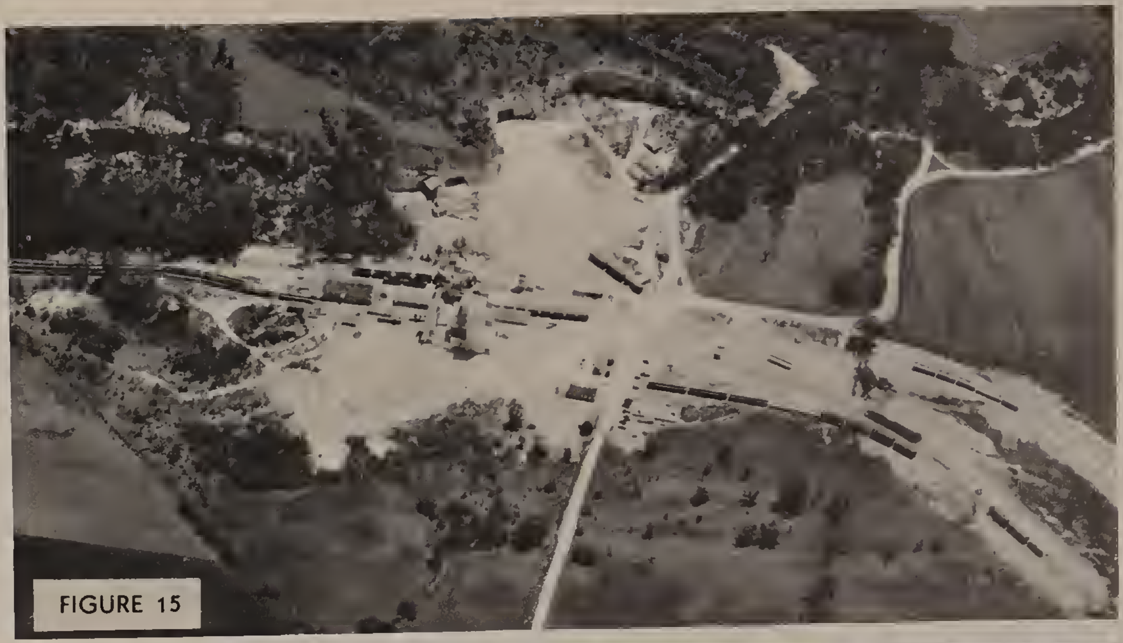


FIGURE 15

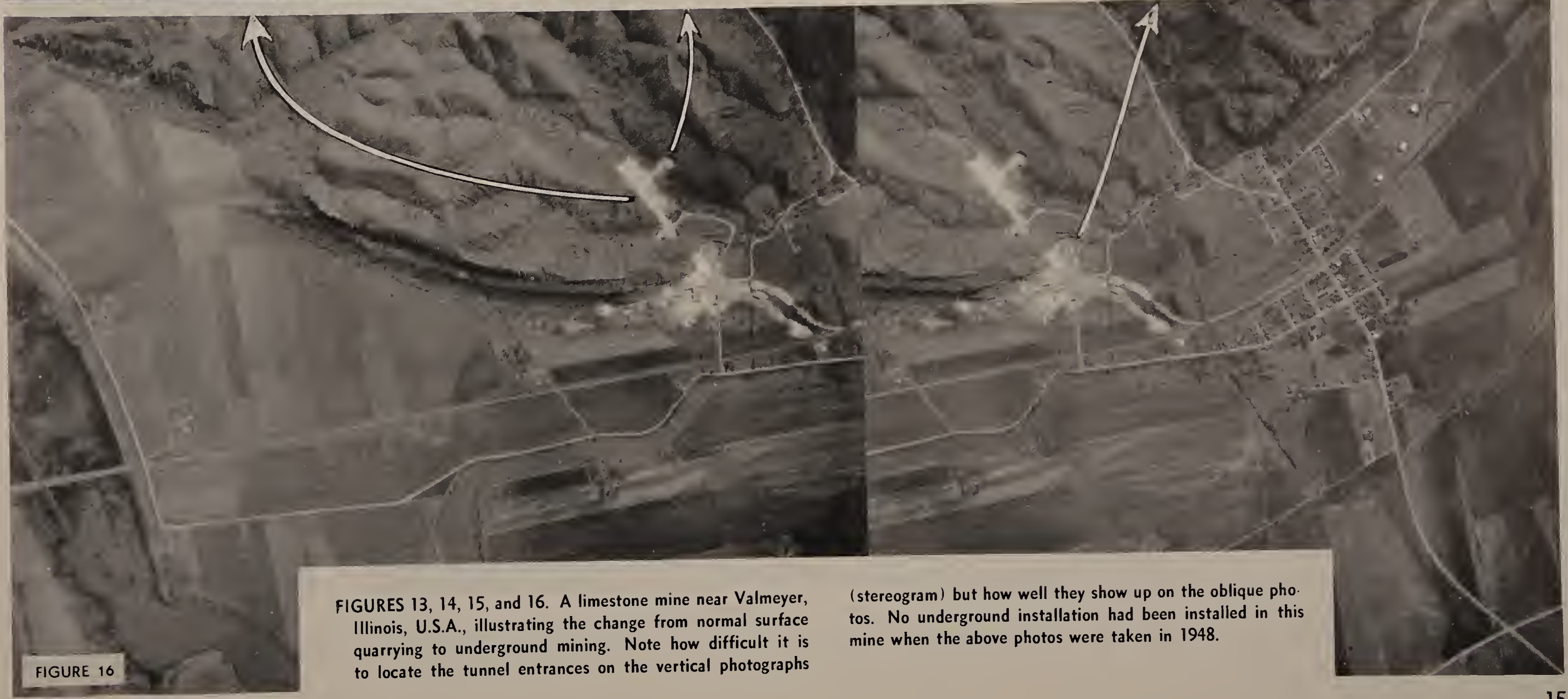


FIGURE 16

FIGURES 13, 14, 15, and 16. A limestone mine near Valmeyer, Illinois, U.S.A., illustrating the change from normal surface quarrying to underground mining. Note how difficult it is to locate the tunnel entrances on the vertical photographs (stereogram) but how well they show up on the oblique photos. No underground installation had been installed in this mine when the above photos were taken in 1948.

In the excavation of galleries and chambers for World War II underground installations it was common practice to dump the waste rock in heaps or piles near the tunnel entrances. This practice was motivated by economy and the desire for a rapid turn-about rate for the haulage equipment. In spite of the fact that these waste dumps or spoil heaps stand out like signposts pointing to the new excavations only a few sites are known where the spoil was disposed of at a sufficient distance to conceal its origin. Instead, the spoil almost invariably was dumped near the tunnel entrances. In some cases attempts were made to spread the spoil evenly on the ground or under trees and to camouflage it by spraying it with paint or by covering it with soil planted in grass. These attempts to camouflage or conceal spoil might have been successful in many cases if they had been completed before the sites were photographed. As it was, the late start of the construction programs and the loss of air superiority in Germany and Japan made possible the frequent photo reconnaissance of many underground installations while they were under construction. In this way it was possible to observe, by means of aerial photographs, the continued enlargement of waste dumps at many underground sites and the attempts to camouflage them. The excavation and construction of some sites were monitored for more than a year. From the large size and number of waste dumps it was clear that the tunnels were being excavated for the underground space that they provided rather than for the rock that was removed. Even where the spoil was commercially valuable, as in the case of the anhydrite in the Nordhausen area, the rate of excavation greatly exceeded the rate of consumption or sale of the spoil, contrary to normal commercial practice. The attempts to camouflage the spoil heaps tended to arouse suspicion and in some cases even attracted attention. The practice of spreading spoil out on the ground under trees provided better concealment but was done only on a small scale and is not suitable normally for the disposal of a large quantity of spoil.

Where narrow gauge railway cars are used for hauling the spoil from the tunnels to the waste dump there is a tendency for the waste dump or spoil heap to develop a triangular shape with the apex pointing in the general direction from whence the cars come. These triangular shaped waste dumps sometimes are called spoil flares and when composed of fresh material form prominent recognition features because of their shape, light tone, and oftentimes large size. Waste dumps deposited by other means of transportation also are readily apparent but usually have a less symmetrical shape. The volume of spoil heaps can be estimated and thus a rough approximation of the underground space determined. In general, older spoil flares are darker in tone than newer ones, but there is no absolute correlation between the tone of a spoil flare as it may appear on an aerial photograph and its age because of the possibility of it being camouflaged. Also, variations in tone have been found in some new spoil flares that are composed of different materials.

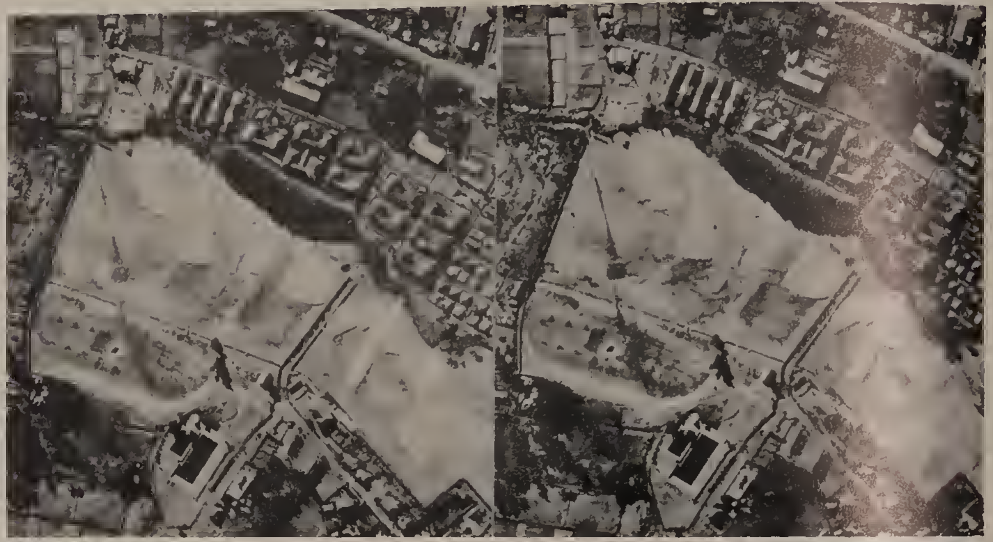


FIGURE 17. Spoil heaps opposite seven tunnel entrances near the Nakajima aircraft factory, Tokyo, Japan.

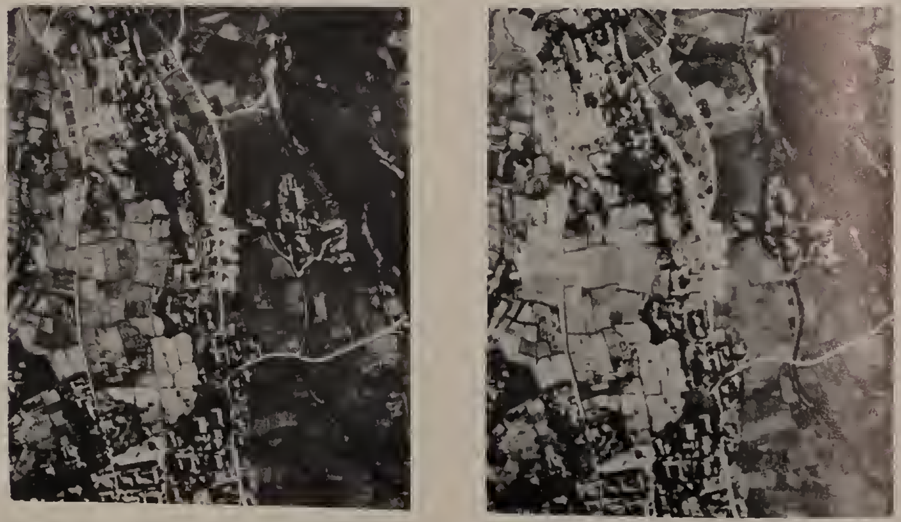


FIGURE 18. Spoil heaps opposite tunnel entrances near the Omura Naval Air Depot, Omura, Japan. Date of photography: 28 May 1945.

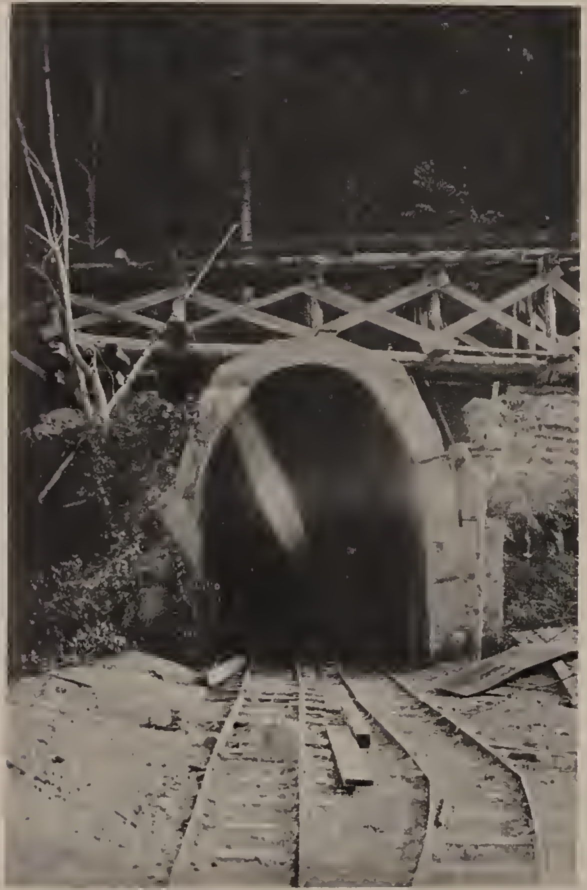


FIGURE 19. Entrance to tunnel No. 1 at the William Metalwaren Fabrik underground factory at Geislingen, U. S. Zone, Germany. Spoil was removed by means of narrow gauge railway dump cars. This tunnel was 8.5 feet wide and 9.8 feet high for the first 200 feet then opened up to 13 feet wide and 14.7 feet high. Total length was 395 feet. Note appearance of this entrance in figures 20 and 21. Photo by A–2, USAFE, 1946.

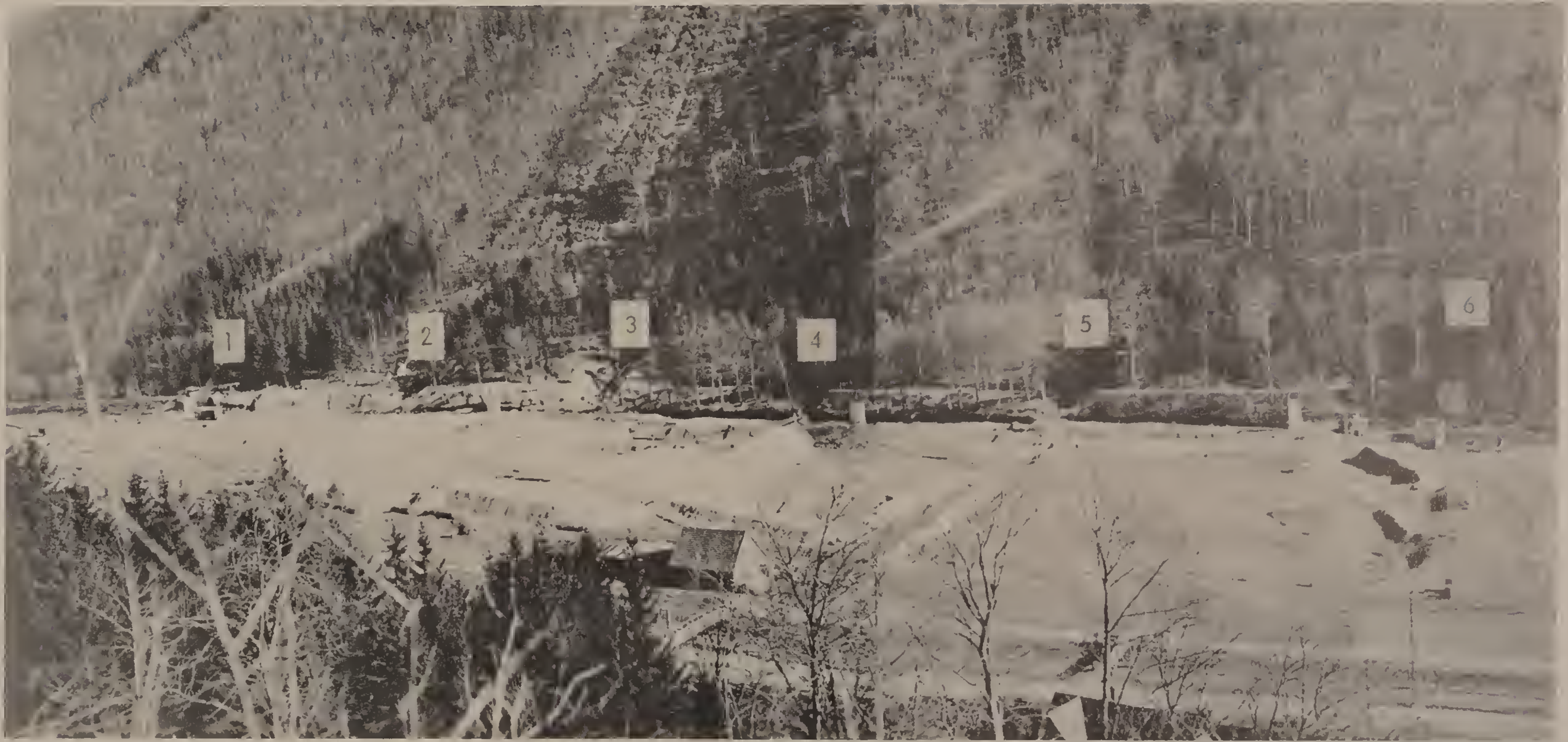


FIGURE 20. Spoil heaps at the Geislingen underground factory shown in figures 19 and 21. Still under construction in 1945, this factory was planned for the production of shell cases, drums for aircraft machine guns and blades for turbo-jet aircraft engines. Of six entrance tunnels and three cross tunnels planned, entrance tunnels 1, 2, 3, and 4 and two cross tunnels were under construction. The sites for entrance tunnels 5 and 6 had been cleared of trees. The entrances to tunnels No. 2 and 3 were blown up by U. S. Army Engineers. Photo by A–2, USAFE, 1946.

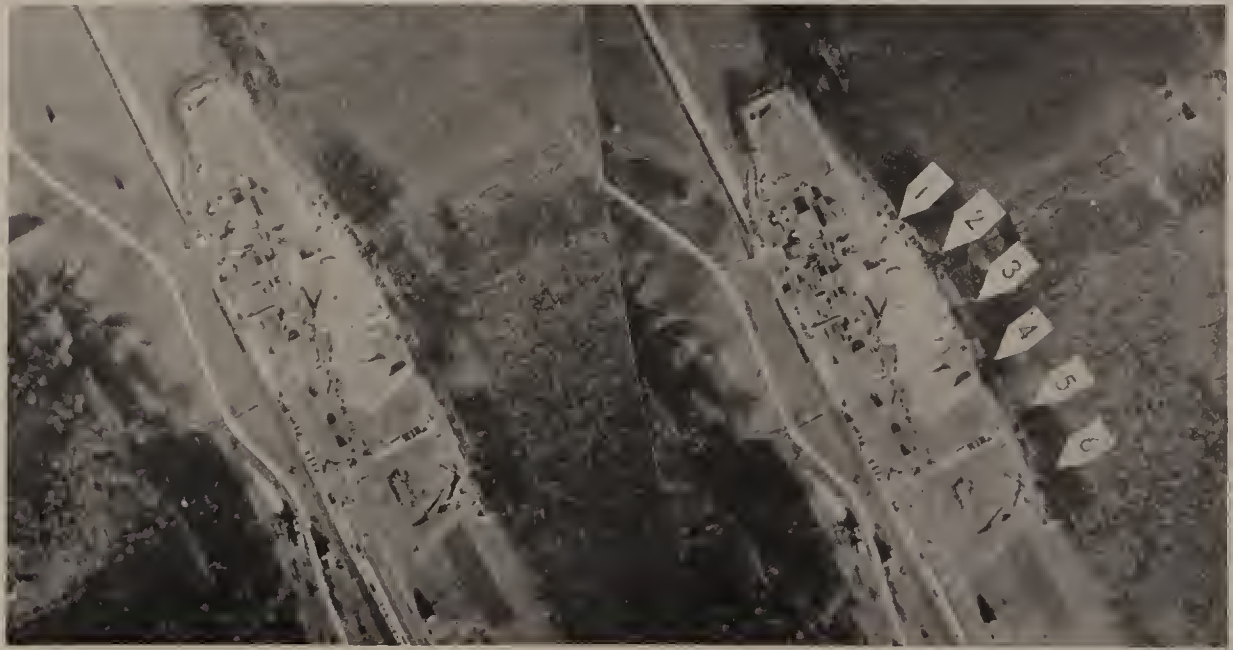
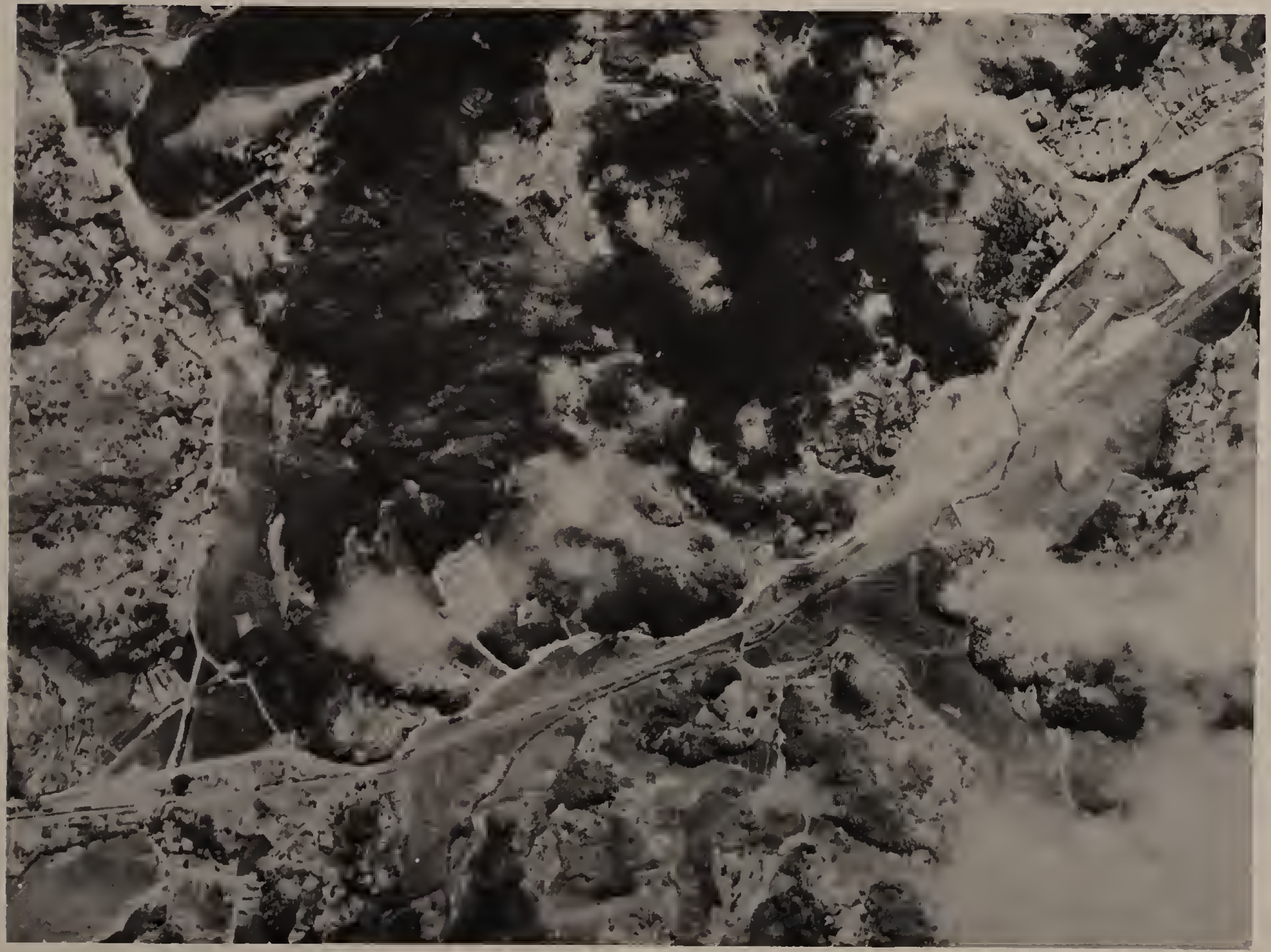


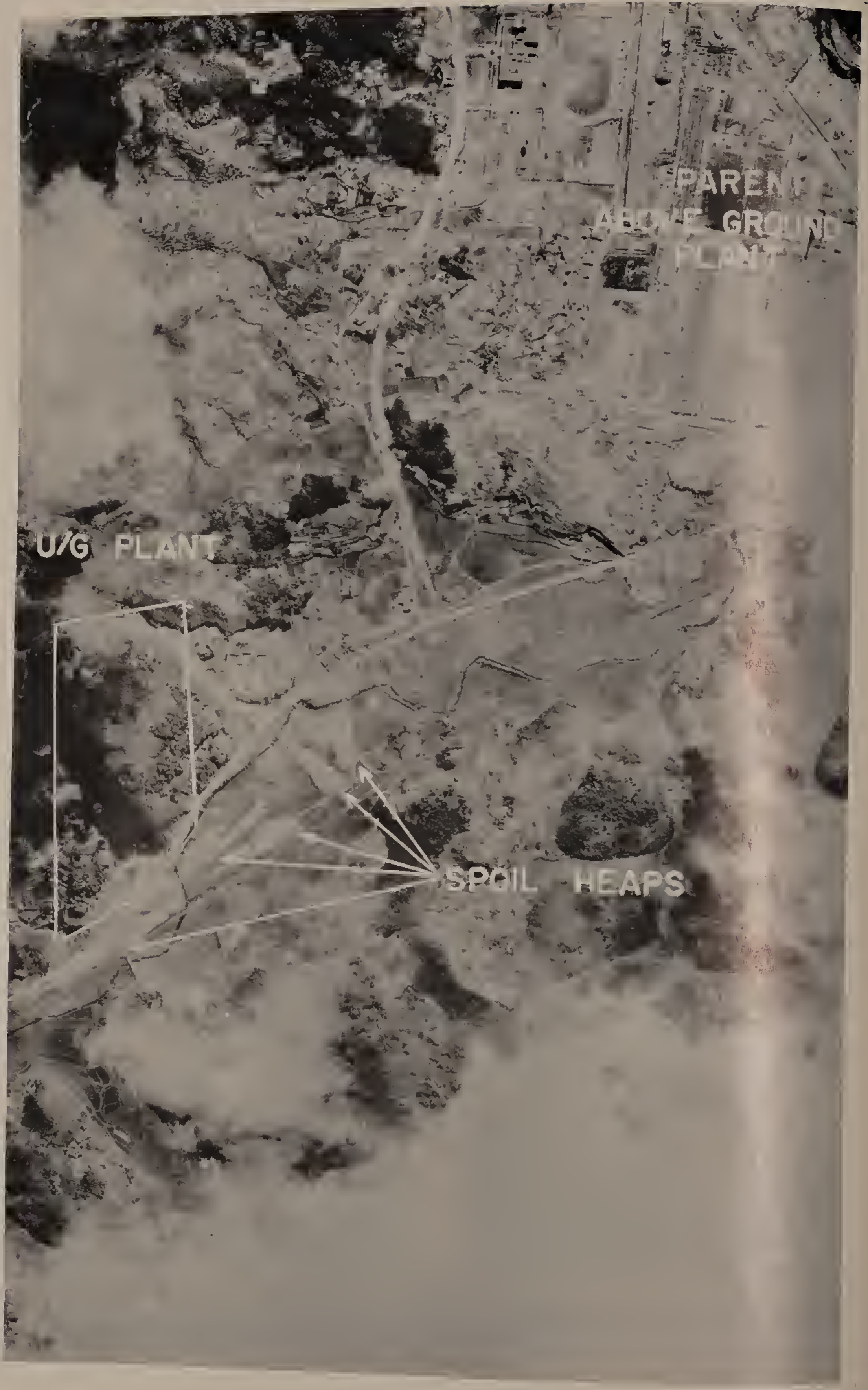
FIGURE 21. Stereogram of Geislingen underground factory shown in figure 20. Note spoil heaps, appearance of tunnel entrances, building materials, and contractors buildings.

Cover: Prints 3114, 4115 of Sortie 106G/4796, dated 4 Mar 1945.

FIGURE 22. Spoil heaps near underground dispersal plant of the Mitsubishi Torpedo Works, Nagasaki, Japan. Six large tunnels, under construction extend entirely through a hill located about 2000 yards NW of the main above ground plant. These six tunnels were excavated in solid rock, were connected midway by a lateral tunnel, were being lined with concrete and the entrances were protected by heavy wooden doors. The spoil was being dumped on spoil heaps in the adjacent valleys. The plant was 50 percent complete and 25 percent of the remaining floor space planned was ready for installation of machine tools. This plant housed some of the heavy machine tool operations of the torpedo assembly department and machined and finished pistons, connecting rods, wrist pins, valve tappets and other small parts from raw steel, bronze, and aluminum alloy castings. This plant employed approximately 2,500 workers and was in operation at the time of the atomic bomb explosion. It is reliably reported that no lives were lost or injuries sustained by employees, in the tunnels, the only damage incurred being at the tunnel entrances where three of the six doors were partially pushed in and shattered by the impact of the bomb blast. Adjacent above ground buildings and the main above ground plant were destroyed with high loss of life.

Cover: Prints 25–26 of Sortie 3L 3PR M51394 20 AF, dated 9 Nov 1945.





Narrow gauge railways are used in many countries on construction and mining projects instead of trucks and heavy trackless earth moving equipment. These narrow gauge railway systems are sometimes known as field railway or as construction railway and are used for hauling bulky or heavy loads such as ore, rock, earth, cement, rubble, and heavy machinery and equipment. In Germany, three different size gauges are used, namely 90 cm, 75 cm, and 60 cm gauge. Meter gauge (100 cm) track is used for local short line railways and in mountainous regions.

Much of the trackage for construction projects, such as the excavation for and the building of underground installations, is laid on a temporary basis and may be shifted about to conform to the progress of the project. Most of it eventually is removed altogether when the project is completed. The use of rails pre-fitted with iron cross ties, somewhat similar to the track for toy trains, is common practice for the smaller gauges and greatly facilitates their use because the pieces of track may be moved from place to place and used again and again without removing the rails from the cross ties. Conventional wooden cross ties are used for track laid on a permanent or semi-permanent basis, for the larger size narrow gauge track and for the smaller gauges where a shortage of rails prefitted with iron cross ties exists. Inside some underground installations narrow gauge track may be laid in cement in the floor of the tunnels as a permanent installation.

Conventional dump cars, small enough for a single car to be pushed by hand, are used in large numbers. These little cars tip sideways and are similar to those used at some coal mines in the United States. Long trains of these cars, pulled by small locomotives, were a common sight at many German underground installations, moving back and forth between the tunnels and the waste dumps. Several different types of locomotives or engines were used to pull these cars. These included steam, electric, diesel, and compressed air engines. Cable car railways, known also as funicular railways and as inclined hoists, were used in Germany at several underground installations.

Features commonly associated with narrow gauge railway systems are loaders of various types, transshipment stations and repair shops.

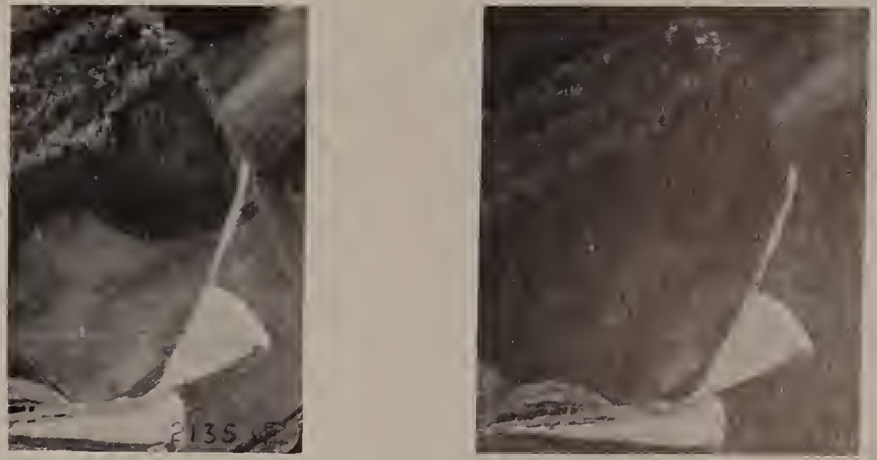


FIGURE 23. Narrow gauge railway dump cars and spoil heaps at Project Zinnstein near Niedersachswerfen, Soviet Zone, Germany. The tunnels, not shown in this stereogram, were being excavated for an underground Junkers jet aircraft engine factory.

Cover: Prints 4201–4202 of Sortie 106G/4779, dated 14 March 1945. Scale: 1:9,000.

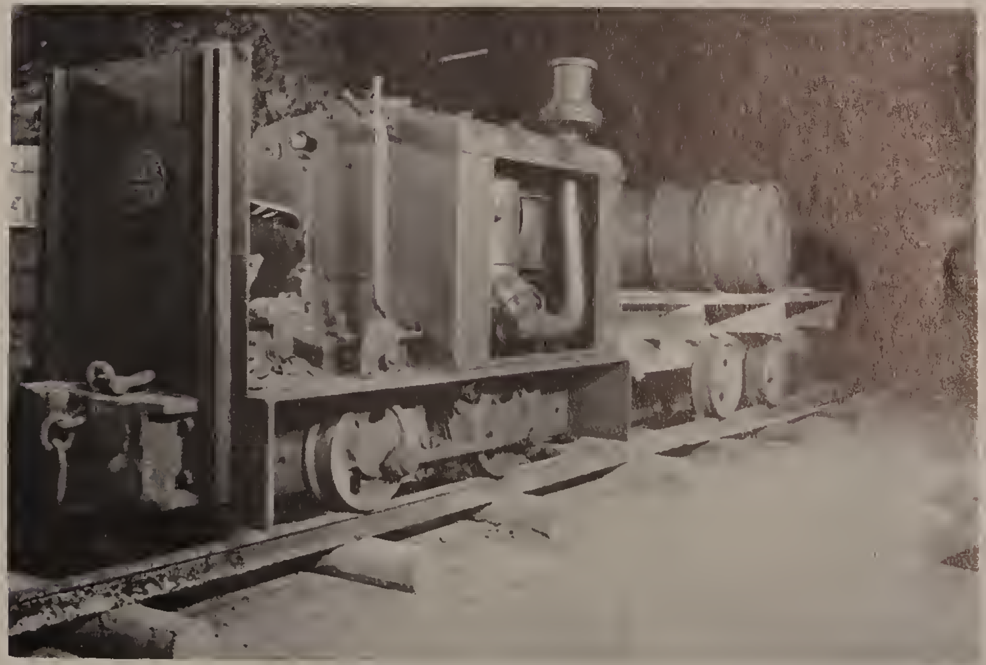


FIGURE 24. Narrow gauge diesel locomotive used in an I. G. Farben underground plant in a salt mine at Heilbronn, U.S. Zone, Germany. Photo by A–2, USAFE, 1946.

FIGURE 25. Narrow gauge railway track at the entrance to tunnel No. 4, William Metalwaren Fabrik underground factory at Geislingen, Germany. Note metal cross ties. This is probably 60 cm gauge track. See also figures 20 and 21. Photo by A–2 USAFE field team, 1946.

FIGURE 26. Narrow gauge railway track at the Nakajima underground aircraft engine factory at Asakawa, Japan. Note similarity of track to that shown in figure 25. Photo by United States Strategic Bombing Survey, 1945.

FIGURE 27. Narrow gauge railway track (90 cm gauge) at Project Dogger, a large underground factory at Happurg, U. S. Zone, Germany. Construction was not completed. Note wooden cross ties and in the background a small locomotive in steam. The wooden structure in the center of the picture is a loading point or tipple and extends from a tunnel at the left. Here spoil from the tunnel was loaded onto dump cars for removal to the waste dump. Photo by A–2 USAFE field team, 1946.

FIGURE 28. Waste dumps, narrow gauge dump cars and locomotives at German underground factories under construction in the east end of the Kohnstein at Niedersachswerfen, Soviet Zone, Germany. Photo by Capt. G. E. D. McBride, CIOS Team 163, 1945.

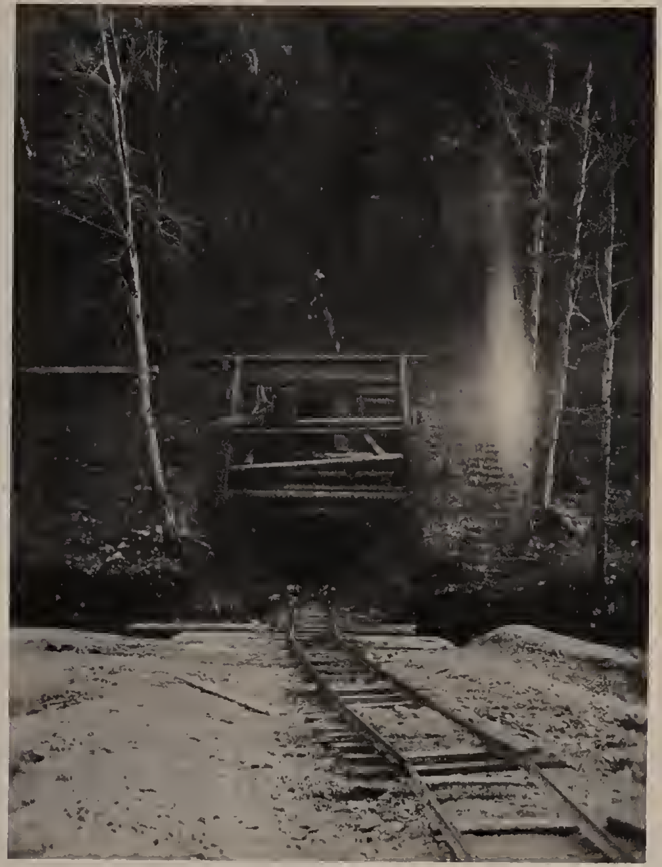


FIGURE 25.

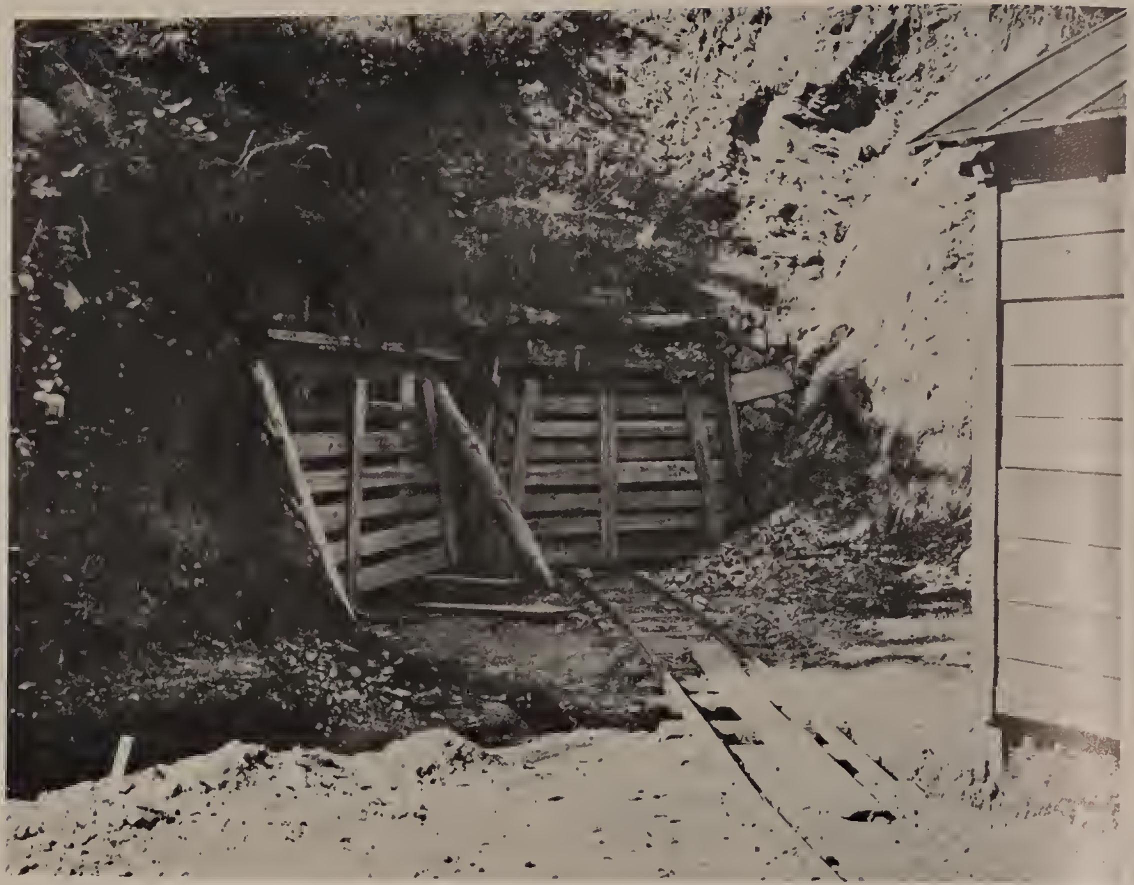


FIGURE 26.

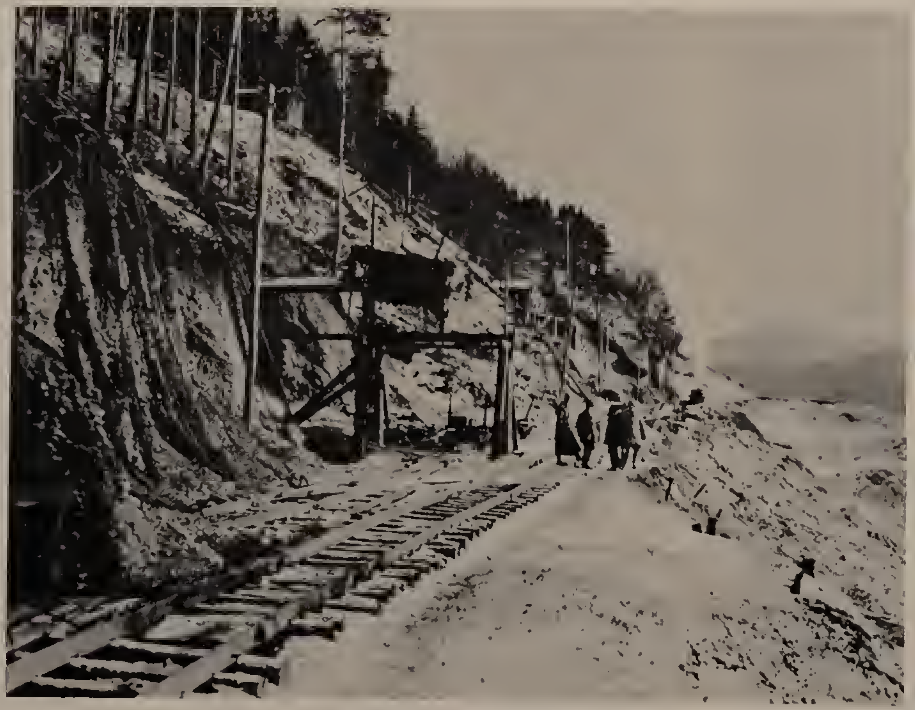


FIGURE 27.

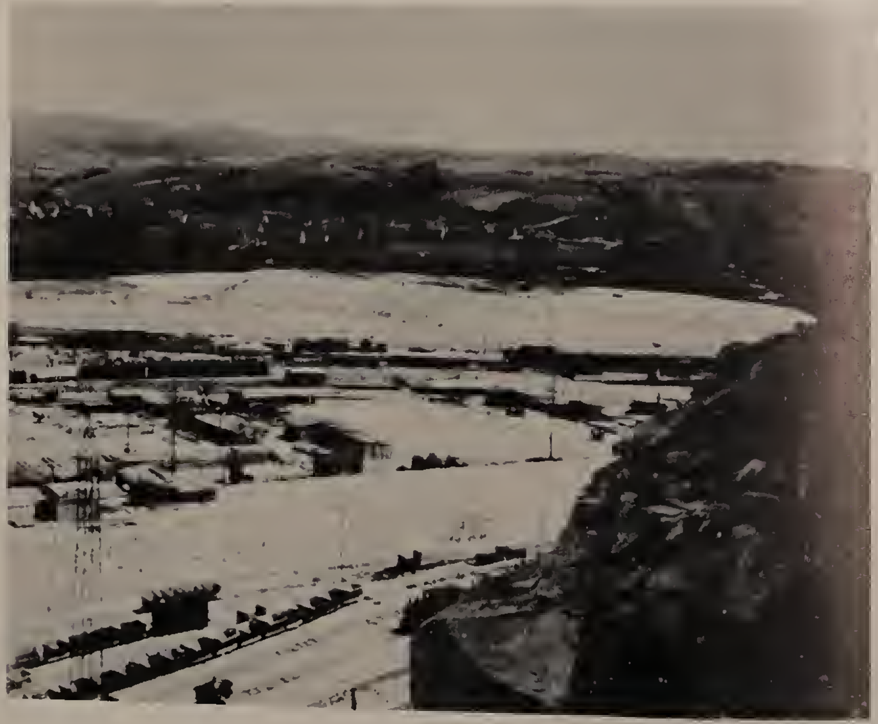


FIGURE 28.

FIGURE 29. Underground factory in a railway tunnel at Langenaubach, U. S. Zone, Germany. Production of aircraft propeller hubs was planned. Note narrow gauge railway track laid on cross ties of standard gauge railway. Photo by A–2, USAFE field team, 1946.

FIGURE 30. Chain operated inclined railway at an underground factory located in a mine near Escherhausen, British Zone, Germany. This narrow gauge railway was used to carry raw material into and finished products out of the factory. This factory produced aircraft components. U. S. Army Signal Corps photo No. SC 205338, dated 1945.

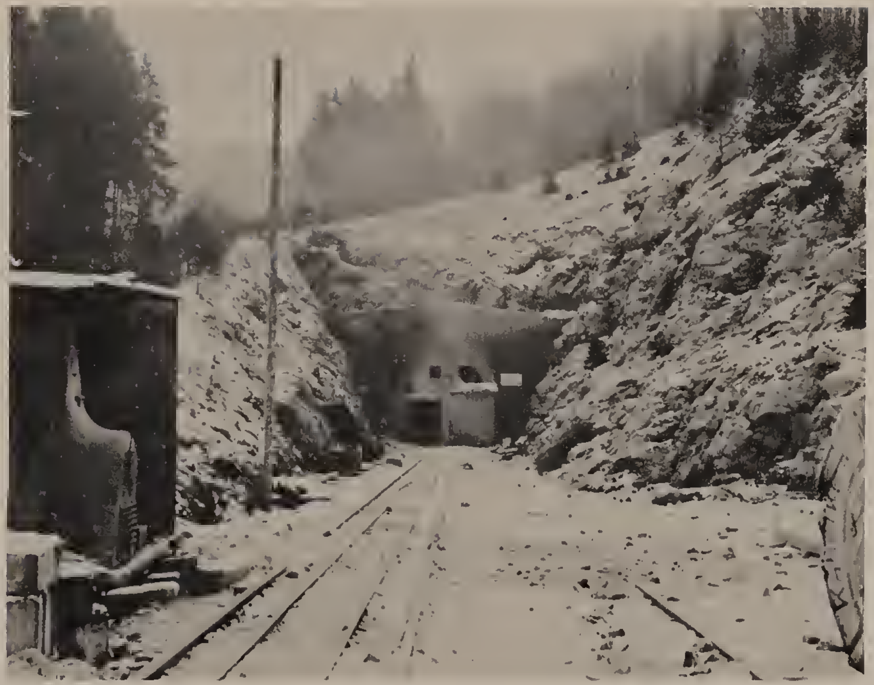


FIGURE 29.

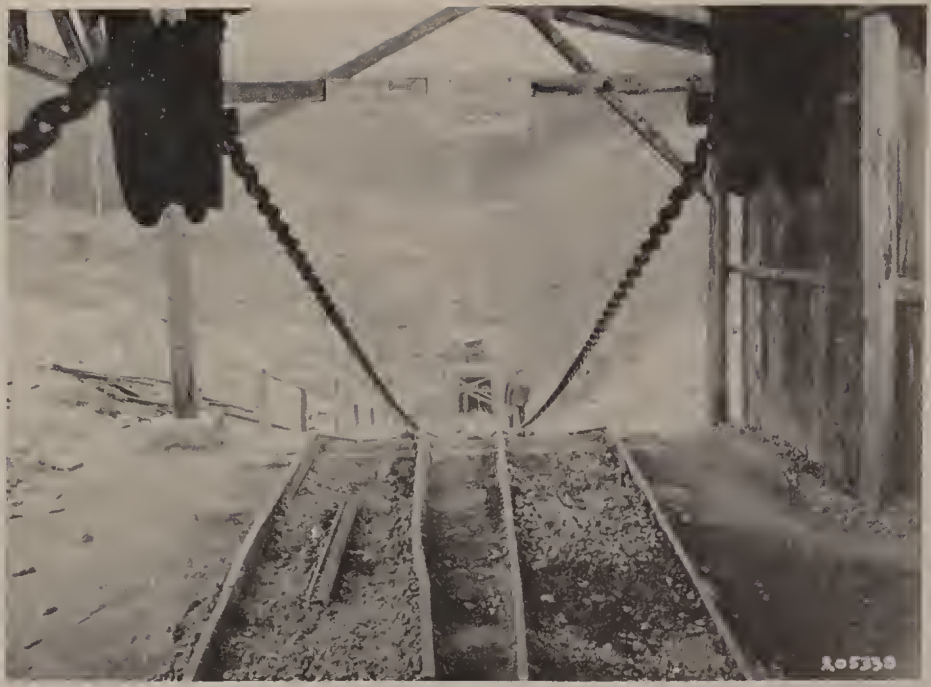


FIGURE 30.

FIGURE 31. Narrow gauge railway flat cars used for moving machine tools into an underground V–1 factory located in an iron ore mine at Thil, France. These cars were pulled by small electric engines. Plans called for the production of 200 flying bombs a month. U. S. Army Signal Corps photo No. ETO–HQ–45–1101, dated 28 Jan 1945.

FIGURE 32. Cable operated inclined railway at an underground factory in a limestone mine at Roigheim, U. S. Zone, Germany. Photo by A–2, USAFE field team, 1946.

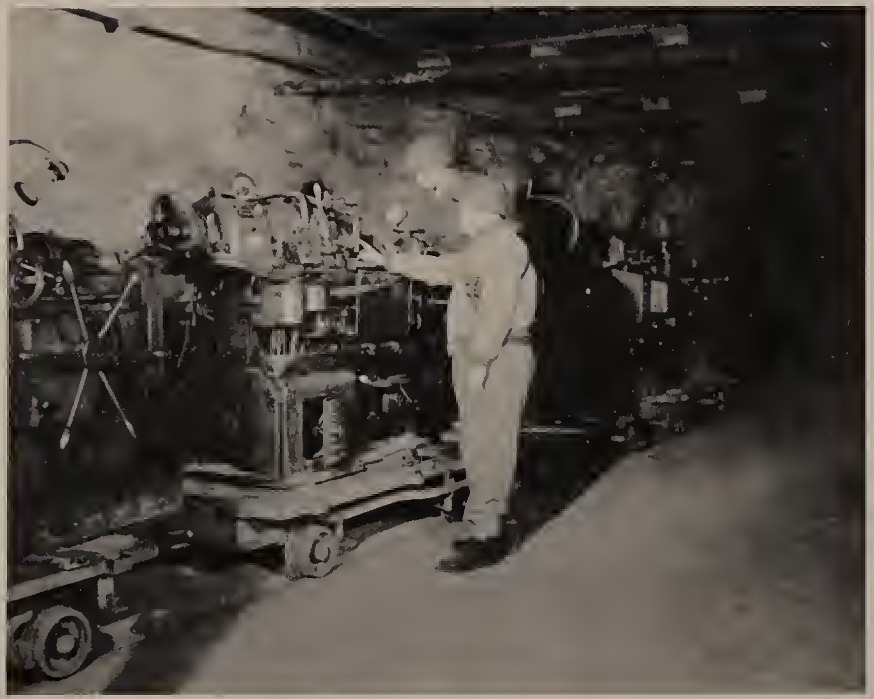


FIGURE 31.

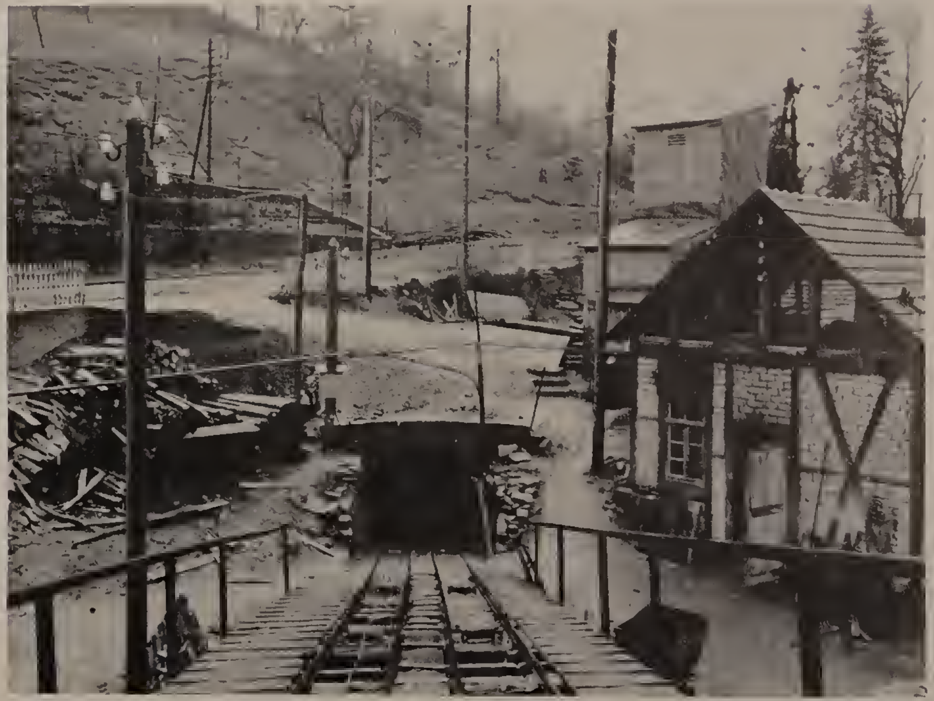


FIGURE 32.

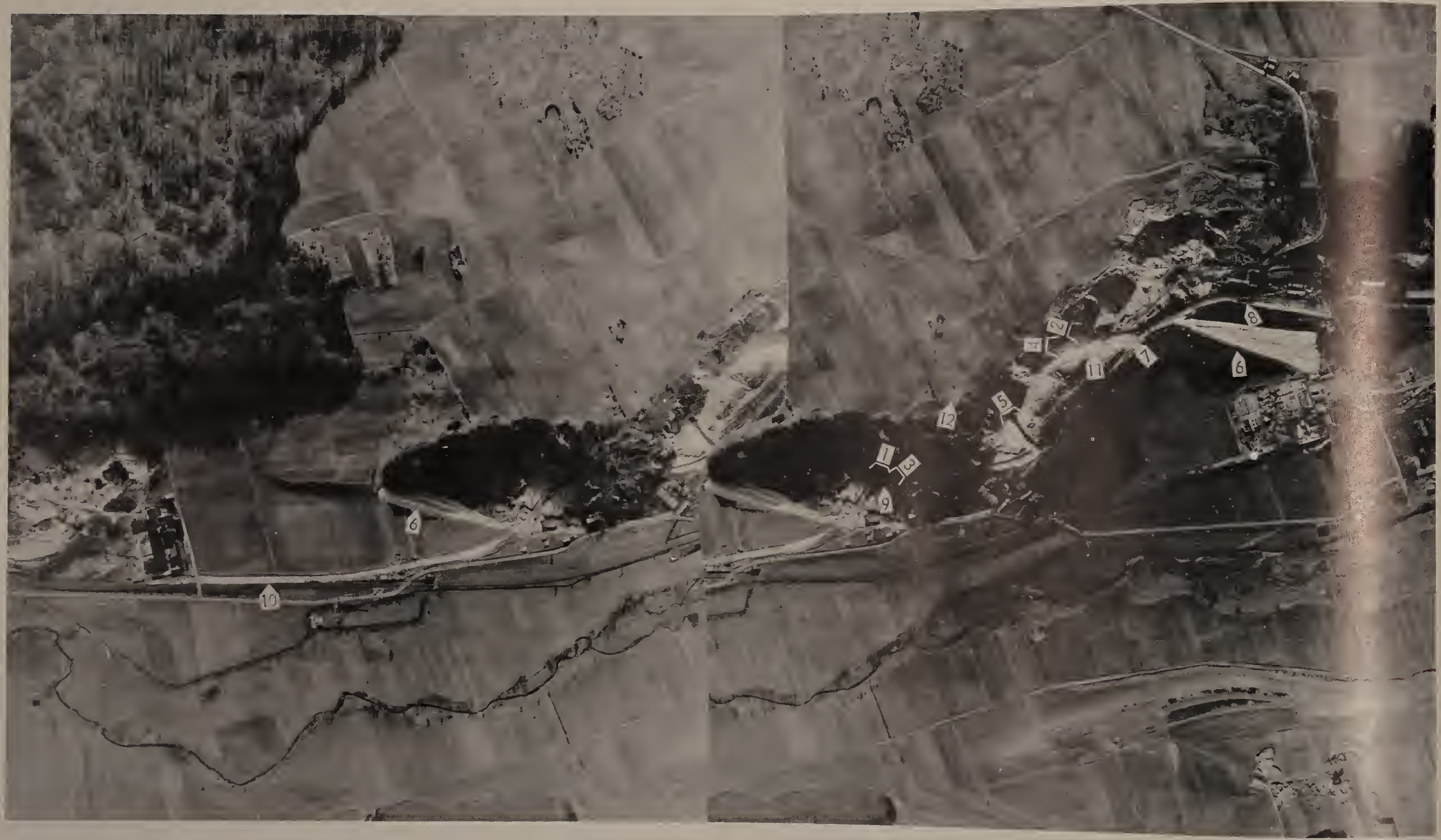


FIGURE 33. Project Kuckuck II, an underground synthetic oil products storage depot under construction in 1945 in the face of old gypsum quarries at Ellrich, Soviet Zone, Germany. Two service tunnels (1–2 and 3–4), approximately parallel and 30 feet wide and 35 feet high, were to be connected by approximately eleven cross tunnels 40 feet wide and 85 feet apart. The cross tunnels were to house the storage tanks. Note the tunnel entrances (1–5), spoil flares (6), narrow gauge railway track (7), dump cars (8), steam locomotives (9), and a standard gauge railway spur under construction (10). Note that in order to bring this spur into the service tunnels it was necessary to excavate deep cuts across the floor of the old quarry (11). The activity on top of the hill (12) above the tunnels is believed to be in connection with the drilling of certain vertical test borings that are shown on a German plan of this underground site.

Cover: Prints 3197–3198 of Sortie 106G/4779, dated 14 March 1945. Scale 1/9,000.

Standard gauge railway spurs and sidings were a common feature at many of the larger German underground factories and storage depots built during World War II. These rail facilities were already available at some of the mines that were taken over and new spurs and sidings were either built, were under construction, or were planned at many of the large new hillside sites that were being excavated when the war ended. These railway spurs and the rail traffic on them proved to be useful keys to the photo interpreter. Studies of the rail traffic at some of the old mines indicated that they had been taken over for a new purpose and in some cases the discovery of special types of railway cars, such as oil tank cars and liquid oxygen tank cars, tended to confirm ground reports regarding the types of installations built in the mines (oil storage depot in salt mine at Strassfurt and liquid oxygen plant in limestone mine at Wittring, for example).

The new spurs and sidings that were built or that were under construction at the new hillside sites were in themselves an indication of the relative importance and size of these new underground installations. Many of these standard gauge spurs, unlike those at normal commercial mines, extended into the underground installations by means of a transportation tunnel so that loading and unloading of standard gauge cars could be done underground. In some cases the transportation tunnels passed all the way through the hill. In other cases they curved in such a way as to emerge from the same side of the hill in which they entered. In addition, many of the large German underground factories and oil installations that were still in the planning stage or early construction stage were to have been provided with underground standard gauge railway sidings. The purpose of placing these sidings underground was to facilitate loading and unloading as well as to provide protection against aerial bombing. This one feature, the extension of a standard gauge spur into an underground installation, is contrary to normal mining procedure and is not known to exist at any commercial mine anywhere in the world, although there may be exceptions. It is, therefore, one of the more significant keys to the identification of underground industrial installations, such as factories and storage depots, and serves to distinguish them from normal commercial mines. Associated features or keys should prevent confusion with an ordinary railway tunnel.

Standard gauge railway transportation tunnels were planned at Japanese underground industrial installations and also have been incorporated in preliminary plans for underground installations in the United States. They should be anticipated in other countries as well because they are a practical and desirable feature at many underground installations. They should not be expected at all such installations, however, because some plants can be served quite satisfactorily by trucks while others may be too poorly located to make such a project feasible.

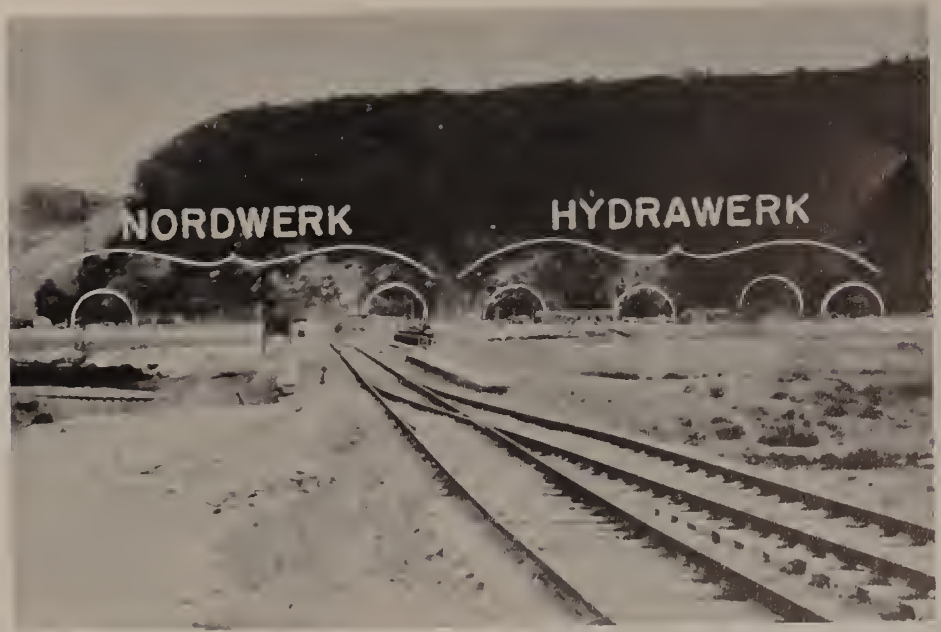


FIGURE 34. Standard gauge railway spur at a Junkers underground aircraft engine factory (Nordwerk) located in the northern part of the hill which contained the underground V–2 factory at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. This view, looking south, shows the two entrances to Nordwerk as well as four entrances to Project Zinnstein. See figure 1. Standard gauge railway track entered both tunnels at Nordwerk. Photo by CIOS Team 163, 1945.

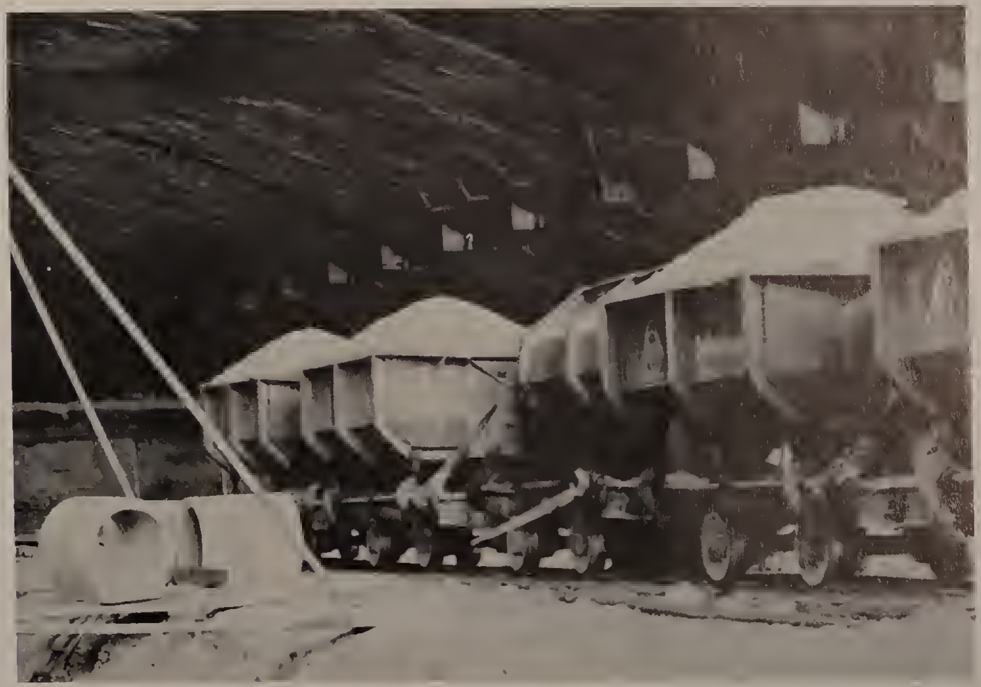


FIGURE 35. Standard gauge railway dump cars at the semi-underground factory building (Bunkerwerke) at Muhldorf, U. S. Zone, Germany. Air Force photo No. C–57936 AC.

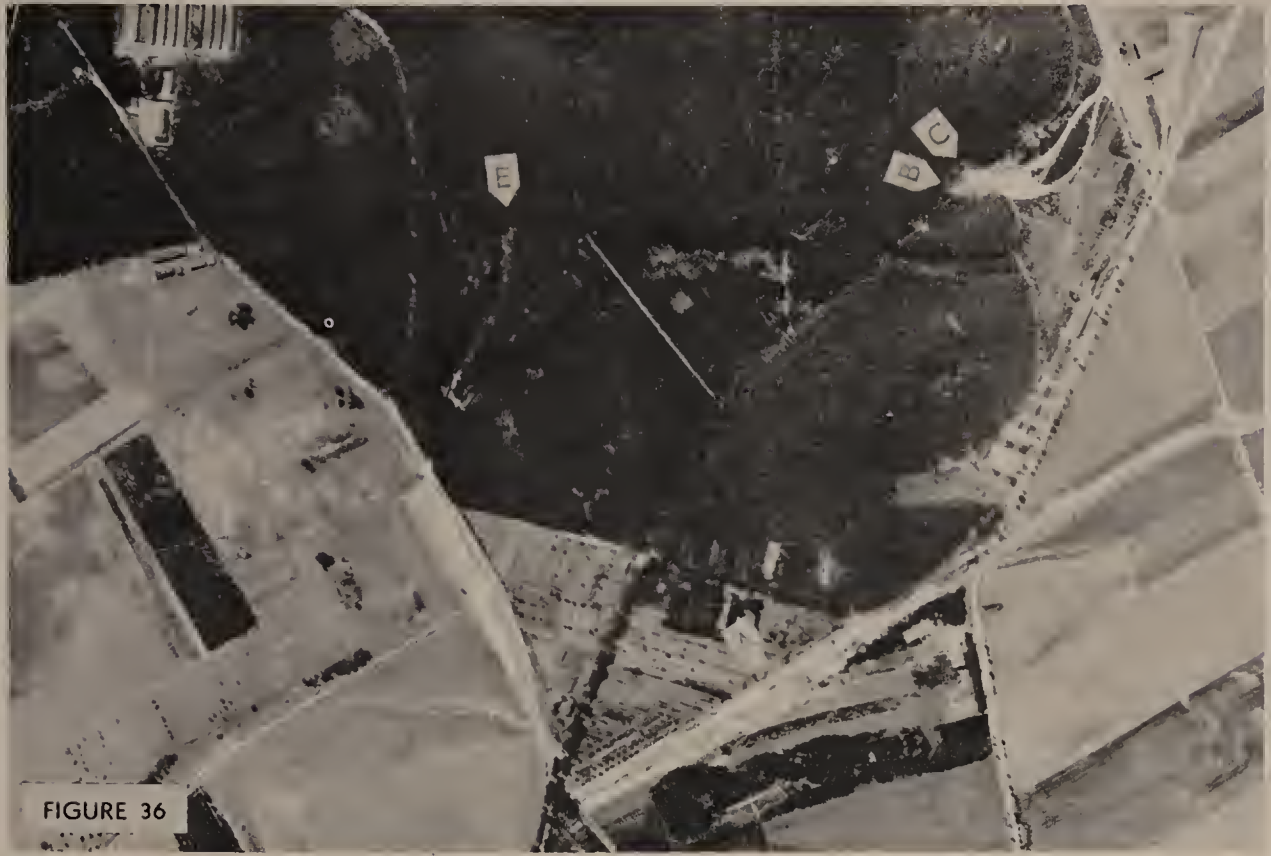


FIGURE 36

FIGURE 36. Underground jet engine components factory at Langenstein, Soviet Zone, Germany. Note standard gauge railway spur and sidings (A), tunnel entrances (B, C, and E) and spoil flares opposite the tunnels.

Cover: Print 4019 of Sortie US 7 Group/2995, dated 16 Aug 1944.

FIGURE 37. Same installation shown in Fig. 36 but seven months later. Note the many changes that have taken place: extension of the standard gauge railway to tunnels B and C, a new railway tunnel (D) and construction work on a roadbed leading to it, new buildings, outdoor storage of materials and transfer stage opposite tunnel D for transferring spoil from 60 cm gauge dump cars to 75 cm gauge cars. A similar stage is shown in Fig. 36 opposite tunnels B and C but was later removed. Note camouflaged spoil flare opposite tunnel D. Note crane and hoist at F. Cover: Prints 3229–3231 of Sortie 106G/5050 dated 23 Mar 1945.
These prints do not cover the entire installation.

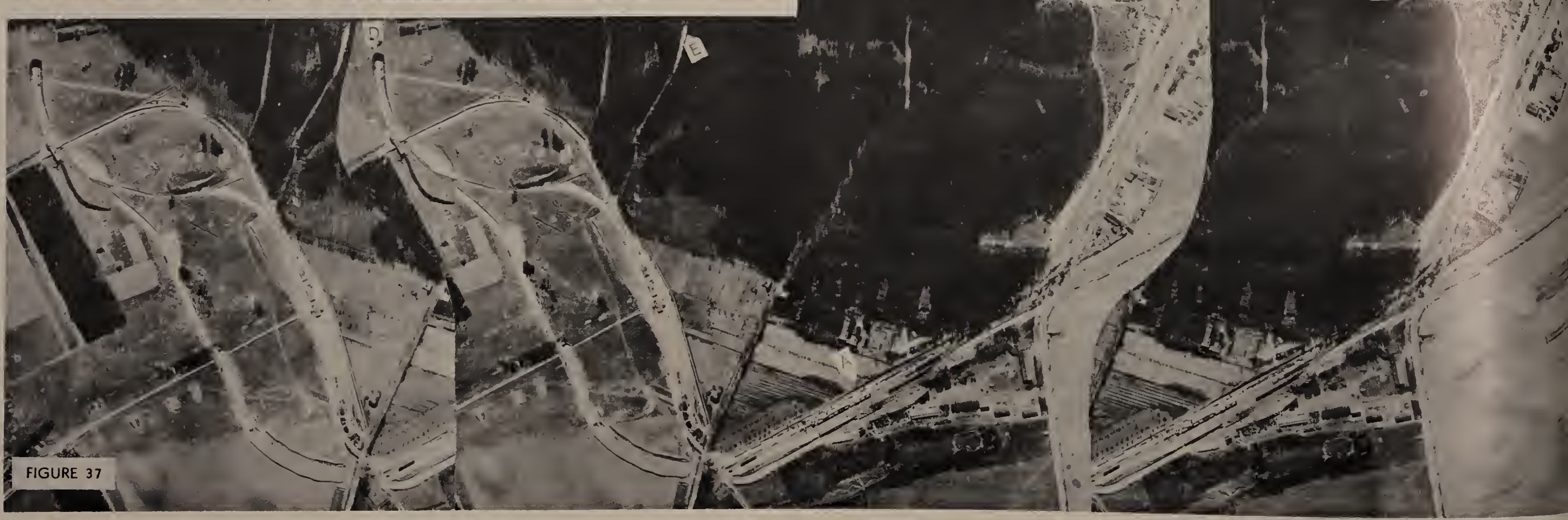


FIGURE 37

Roads, footpaths and track activity are common features at underground sites and are quite useful in the photo interpretation of such installations, especially during the construction stage. Comparative cover, taken over as long a period of time as possible, should be used in order to observe changes and also because some track activity is only visible for a short time. Snow cover also is useful because it may show track activity which would not be visible on nonsnow cover. All roads and footpaths in the area surrounding the suspected underground site should be traced in order to see what they lead to or connect. Roads oftentimes lead direct to tunnel entrances, thus revealing their location. Also, roads may lead from the entrances to above ground buildings, facilities and utilities and thus indicate which of these belong to the underground project. The width, condition, and apparent age of these roads give some indication of the size and status of the installation. It is important that all footpaths and track activity on top of the hill in which tunnels are suspected or have been found be studied carefully because they may lead to the discovery of vertical test borings (Figs. 1–3), ventilation shafts, and chimneys.

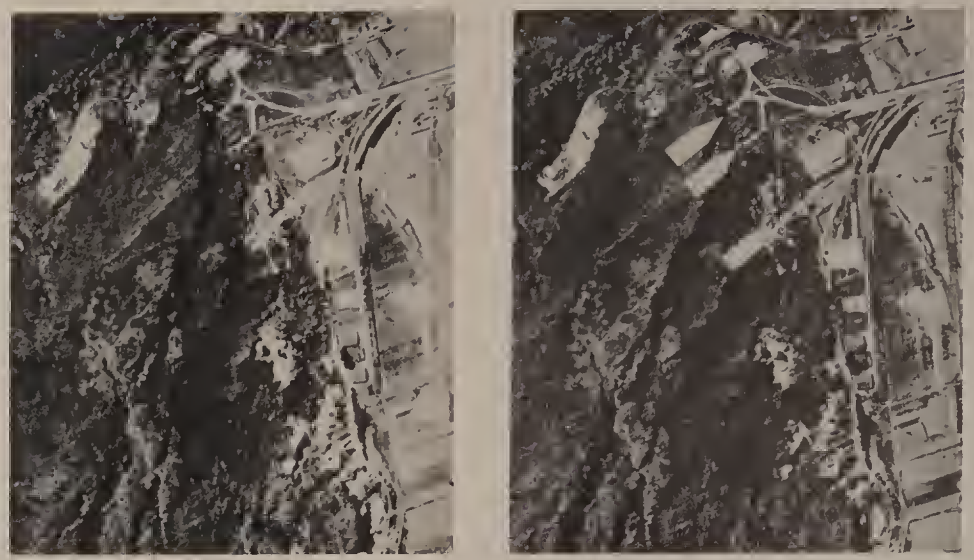


FIGURE 38. Okayana, Formosa. Note the three tunnel entrances with roads leading to them and old narrow gauge railway roadbeds leading from them to waste dumps. Note also the two standard gauge railway sidings. This underground installation is connected by road and rail with an aircraft factory at Okayana three miles to the west. CFL No. 1807435.

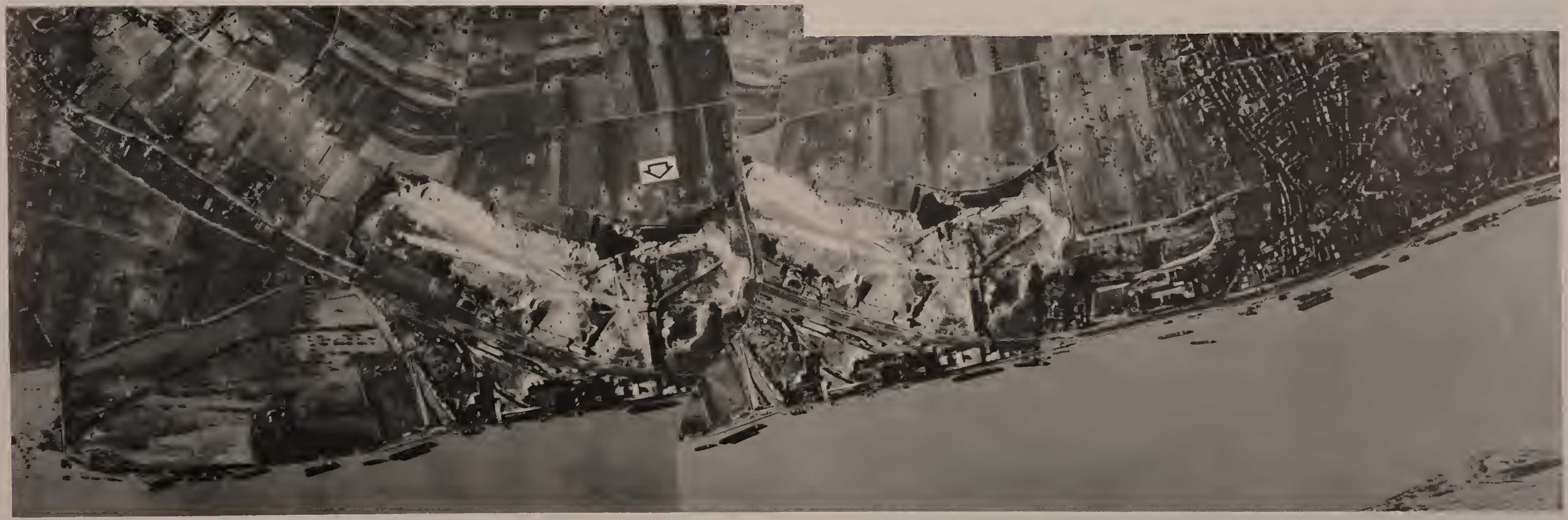


FIGURE 39. Underground factory in new tunnels in cliff of limestone quarry at Weisenau near Mainz, French Zone, Germany. The three paths at the top of the cliff converge at the site of a vertical shaft excavated for removing used air from the factory. A smoke shaft and another air shaft were planned. The tunnel entrances are concealed by shadow from the cliff on this photography but are visible on other sorties. This factory had a floor space of 43,040 square feet and manufactured launching tubes for V–1 flying bombs.

Cover: Prints 3055–3056 of Sortie US7/82A, dated 14 Feb 1945. Scale: 1/12,800.

Aerial tramways, also known as ropeways, transport loads in carriers suspended from wire cables forming the tracks, between fixed points, usually a long distance apart. An aerial cableway transports loads for a short distance, in a single carrier traveling back and forth on a single cable, or on multiple cables, a hoisting operation being combined with the transfer of the load; the operation is intermittent. Cableways are used on open excavations for sewers, canals, dams, and strip mines. Aerial tramways are used for transporting ore, coal, salt, and other raw materials from mines to processing plants or to railroads. They also can be used for hauling a variety of material and workmen to the mines. Some mines have no other means of transport in winter.

In Germany, aerial tramways are utilized extensively in salt and coal mining regions. When many of the German salt mines were utilized for underground factories and storage depots in World War II many tramways were thus available for conveying material both to and from these installations. The extent of use, however, is not fully known. A few tramways were built at new underground sites where tunnels were being excavated in the side of a hill. One of these sites was at Happurg, U. S. Zone, Germany, where access to the tunnels was difficult by road and rail because of earth slides and the height of the tunnels above the valley floor. Two aerial tramways were built at this site for hauling concrete up to the tunnels.

There are three types of aerial tramways: bi-cable, twin-cable, and mono-cable. Bi-cable tramways have a fixed track cable along which the carriers are hauled by a traction cable. Twin-cable tramways are similar, except that carriers run on a pair of track cables. Mono-cable tramways have a single running cable to support and move the carriers. Some tramways are reversible. On continuous tramways a series of loaded carriers travel in one direction and empty carriers return in the other direction.

The carrier consists of: carriage, container, hanger and clamp for attaching the hanger to the traction cable. The carriage which runs on the track cable, has either two or four wheels. The container may be a bucket, tank, cage, or platform. Hooks and chain slings are used for hauling timber. The clamp may be either a grip or a clip. A grip can be applied or released at will so that the carrier can be easily detached from the traction cable at the loading and unloading terminals. A clip attaches the carrier to the cable by a metal strap and bolts. It is a more or less permanent attachment. Clips are obsolete.

There are several different types of stations associated with aerial tramways. All of them are in direct line with the tramway and are usually covered by a roof. Terminal stations are located at each end of a tramway. They are designed to secure track cables, operate traction cables, transfer carriers from cables to rail, lead them to loading or discharging point and return carriers to the cables. If clips are used the carriers are loaded and unloaded while in motion and while still attached to the traction cable. Carriers on mono-cable tramways may be attached to the running cable by clips or suspended from it by box-heads which ride on the cable and are detached at the terminal for loading and unloading. Box-heads have two side wheels which run on a rail at the various stations. Power for operating aerial tramways may be supplied by either an electric motor or by a gasoline engine. Some tramways are operated by gravity.

The towers or supports for the cables vary in design, size and material from which they are constructed. They may be of either steel or wood and may have two, three, or four legs. They may or may not be

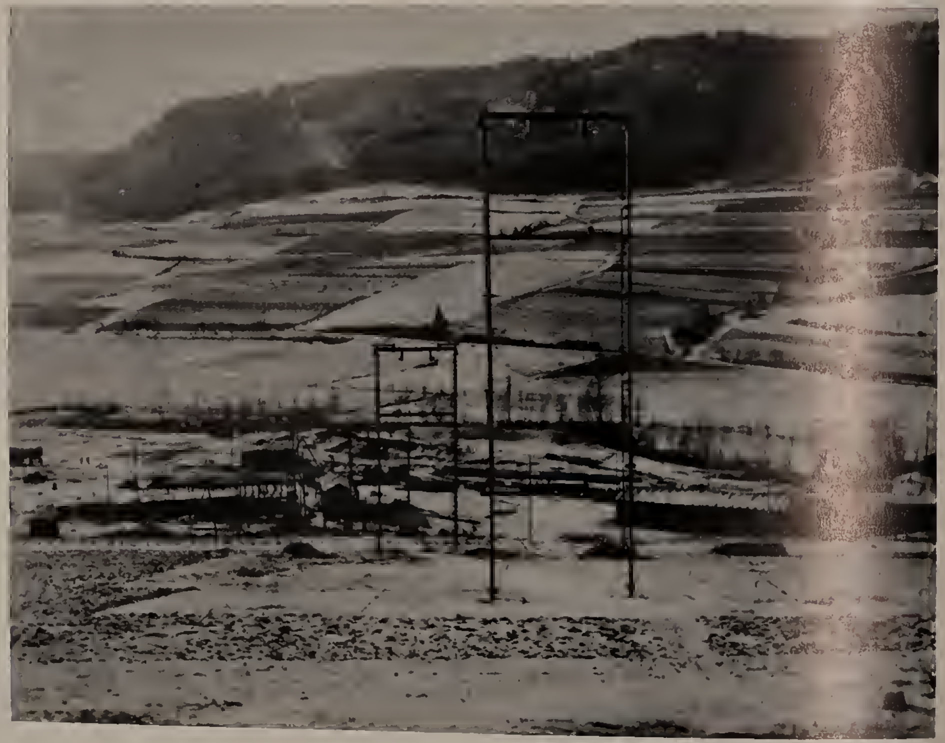


FIGURE 40. Aerial tramway at underground factory under construction at Happurg, U. S. Zone, Germany. View looking down hill away from tunnels and showing steel towers, cables, and guy wires. Used for hauling concrete up hill to tunnels. No carriers visible.

Photo by A–2, USAFE, 1946. AF Photo No. 276582.

secured by guy wires. Foundations may be of concrete, masonry, logs or cribs with or without rock filling. Concrete and masonry towers sometimes are used, especially when the tramway serves a cement plant.

Aerial tramways can be identified on aerial photographs by means of the towers or supports for the cables, by clearings through woods, and on some photography by the cables themselves as well as by the carriers suspended from the cables. The various stations and shed-like structures associated with tramways are useful to the photo interpreter for distinguishing tramways from power lines. Aerial tramways are useful in locating and identifying mines.

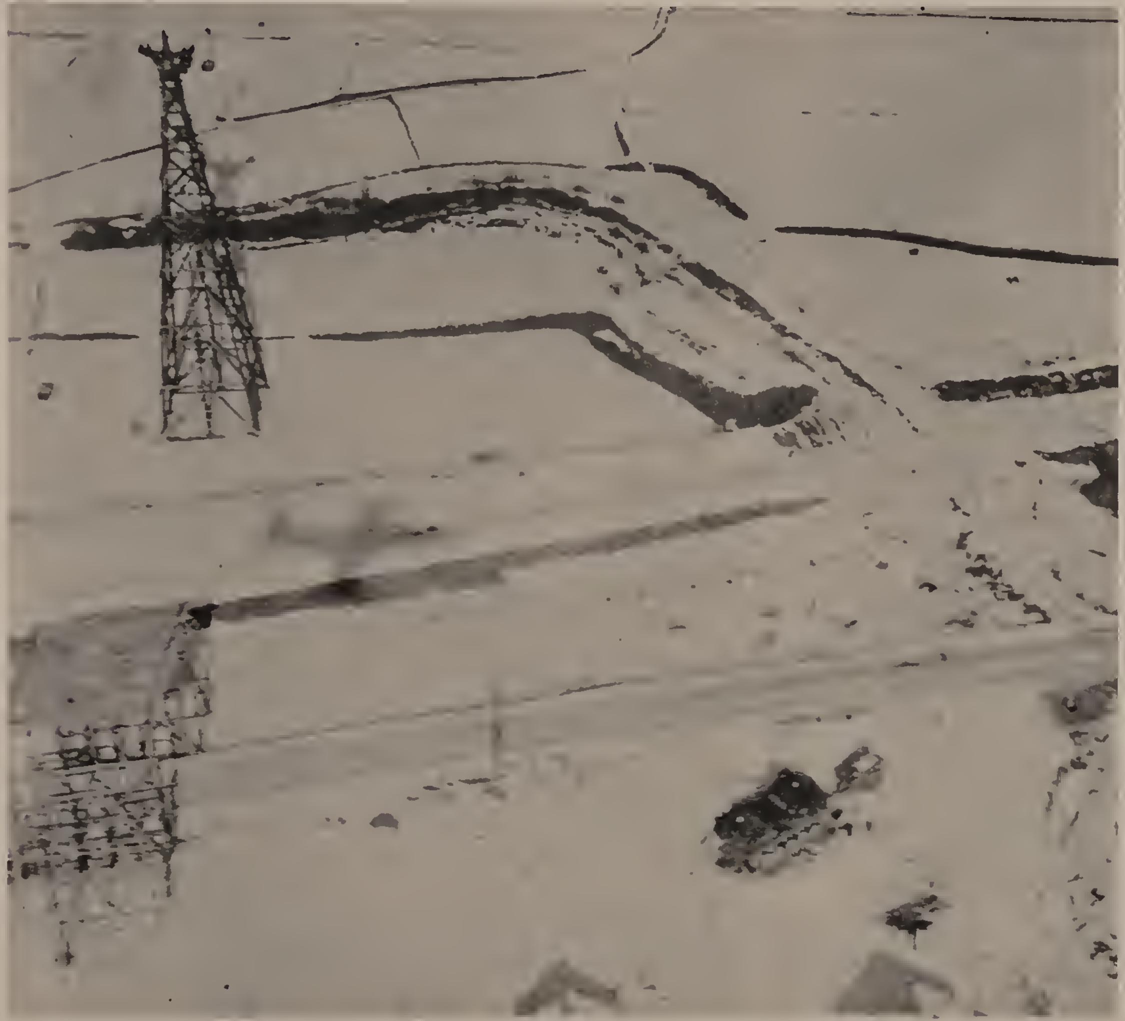


FIGURE 41. Mono-cable aerial tramway one mile west of Unhung-ni, Korea. Note shed-like structure over highway.

Cover: Print 5–0L of Sortie 2407C–8TRS–5AF, dated 24 June 1951.

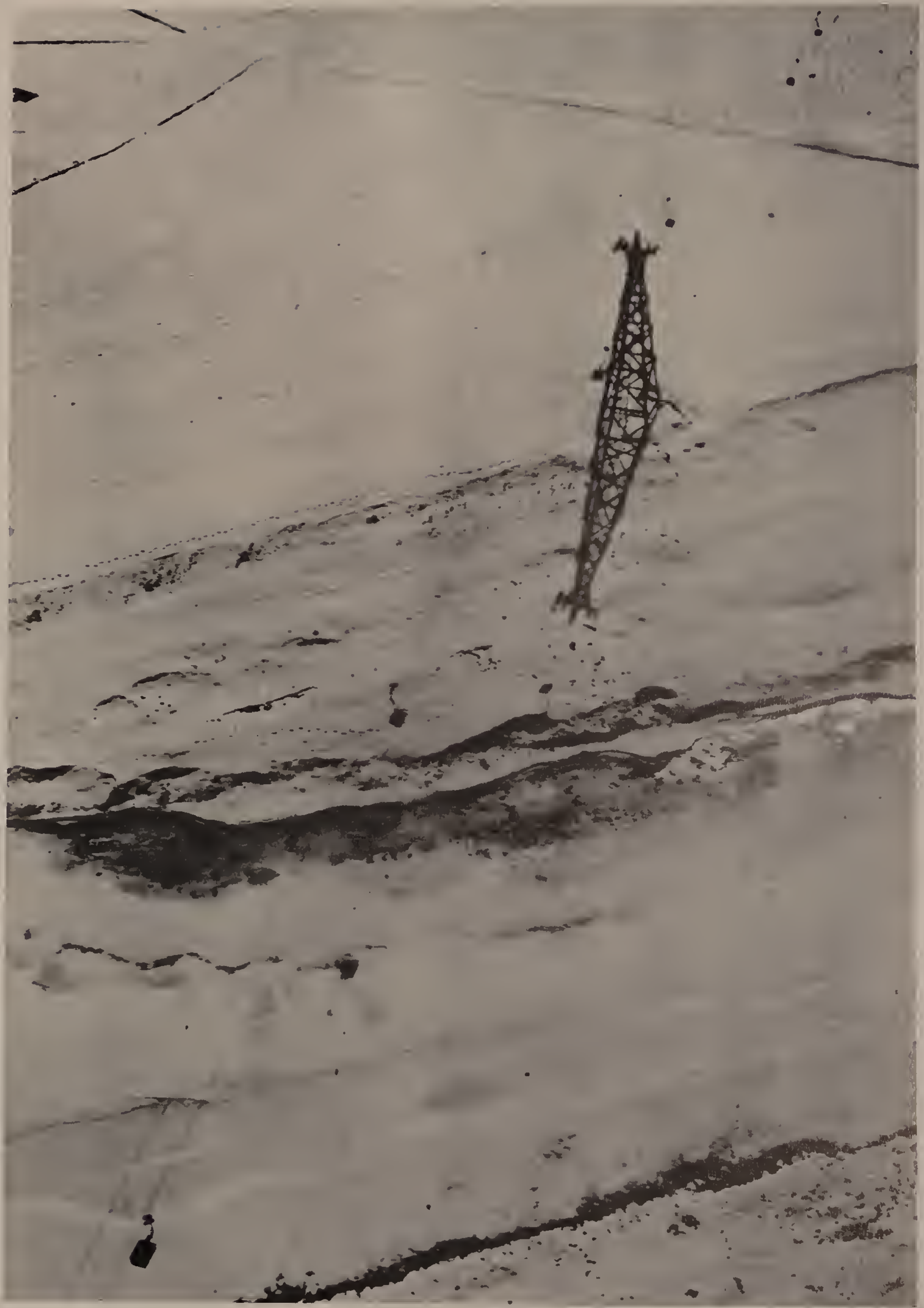


FIGURE 42. Same aerial tramway shown in Fig. 41. Note cables, carriers, shadows and the construction of the towers which are made of wood.

Cover: Print 2–0L of Sortie 2407C–8TRS–5AF, dated 24 June 1951.

Junction stations are practically two terminals placed back to back where two divisions of a long tramway meet. Here, carriers are transferred or switched from the cables of one division to those of another division by means of a short rail. Junction stations are necessary for very long aerial tramways because the maximum length of one division bicable tramway is about four miles. The resulting eight miles of endless traction cable is about as long as can be operated successfully. For tramways longer than four miles a series of tandem tramways, connected by junction stations, can be built. Each division is practically an independent tramway. An aerial tramway in Argentine has eight divisions and is 21 miles long. There may be a deflection, either horizontally or vertically, at junction stations.

Intermediate stations are needed to apply working tension to track cables which are too long for terminal apparatus to be effective throughout. There are three types: double-anchorage; double-tension; anchorage and tension. In all, the track cables are deflected to center of structure, out of the way of carriers, and pass downward to anchorage or to tension weights. Space between sections of track cable is bridged by rails, to allow carriers to pass through without being detached from traction cable. In any aerial tramway the track cables are divided into sections of 3,000 to 5,000 feet each. One end of each section is anchored while tension is applied at the other end.

Angle stations are required for horizontal deflections. The track cables are terminated and the gaps bridged by rails. The traction cables are deflected by large wheels known as sheaves. The carriers detach themselves automatically. At some stations workmen are needed to reattach the carriers to the traction cable. Occasionally, angle stations are designed so that carriers detach and reattach automatically, or are arranged so that they make the turn without being released from the traction cable.

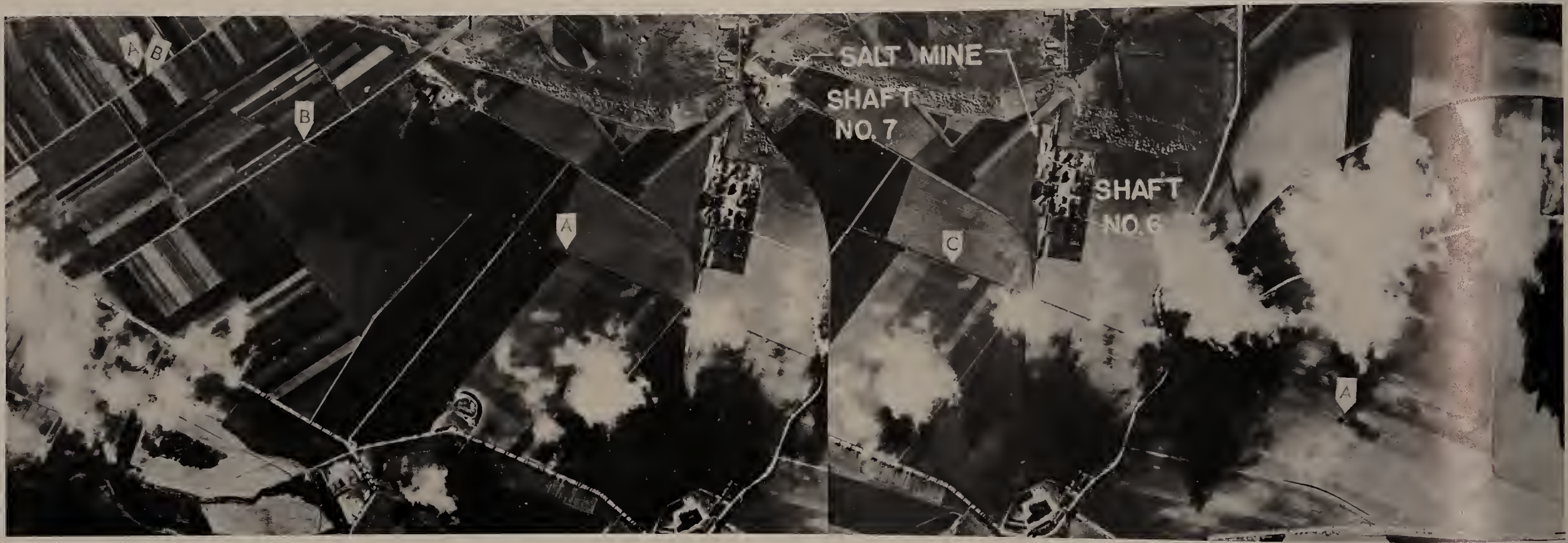


FIGURE 43. Aerial tramway four miles NW of Stassfurt, Soviet Zone, Germany. This tramway extends from a brown coal mine to Stassfurt. Note intermediate stations (A), protective sheds over roads (B), and shadows of towers and carriers (C). Note that the carriers were in motion when the photographs were taken. The salt mine, which is served by two shafts, was 70% tooled for production of BMW 003 jet aircraft engines when World War II ended. Ground reports indicate that the underground factory in this mine was put into production by the Russians and utilized for about a year. Note the open air storage of materials at Shaft No. 7, the new power line leading to Shaft No. 7 and the small group of new buildings near Shaft No. 6.

Cover: Prints 3038–3039 of Sortie 1066G/1064, dated 24 June 1944.

Summit stations are introduced at crests in order to save erection of a group of towers and to prevent a sharp bend in the cables, thus relieving cable wear.

Shed-like structures are built where aerial cableways pass over railroads and main roads. These structures are built in order to prevent material from falling onto the road or railroad from the carriers overhead.

Above-ground buildings are common features at many underground installations built during World War II, especially at newly excavated sites. Many of these buildings were temporary structures erected for use during the excavation of the tunnels and the construction of the underground installation. They include contractors offices, architects offices, mess halls, canteens, latrines, repair shops, tool storage sheds and compressor buildings. Other buildings, related to the actual operation of the underground installation and erected for more or less permanent use, also were built above ground and include storage buildings, guard buildings, transformer buildings (although many transformers were placed underground), water pump houses and small structures at sewage plants.

When sufficient comparative photo cover was available it was possible to follow the progress of the construction of all these various buildings which usually were concentrated near the tunnel entrances. The type of construction utilized included the temporary war-time standardized type, military barrack types with some prefabricated types, and differed greatly from that of the normal local architecture. The arrangement and location of the buildings did not conform to the normal local pattern of development and therefore presented an incongruous and distinctive pattern in itself.

In some cases, where factories were built in highway and railway tunnels, new buildings were built either as an extension of the tunnels or at the tunnel entrances. These buildings blocked the roads and railroads, were quite conspicuous, and thus facilitated the interpretation of these particular underground installations. New buildings also were built at old mines that were converted into underground installations but to a lesser extent than at newly excavated sites.

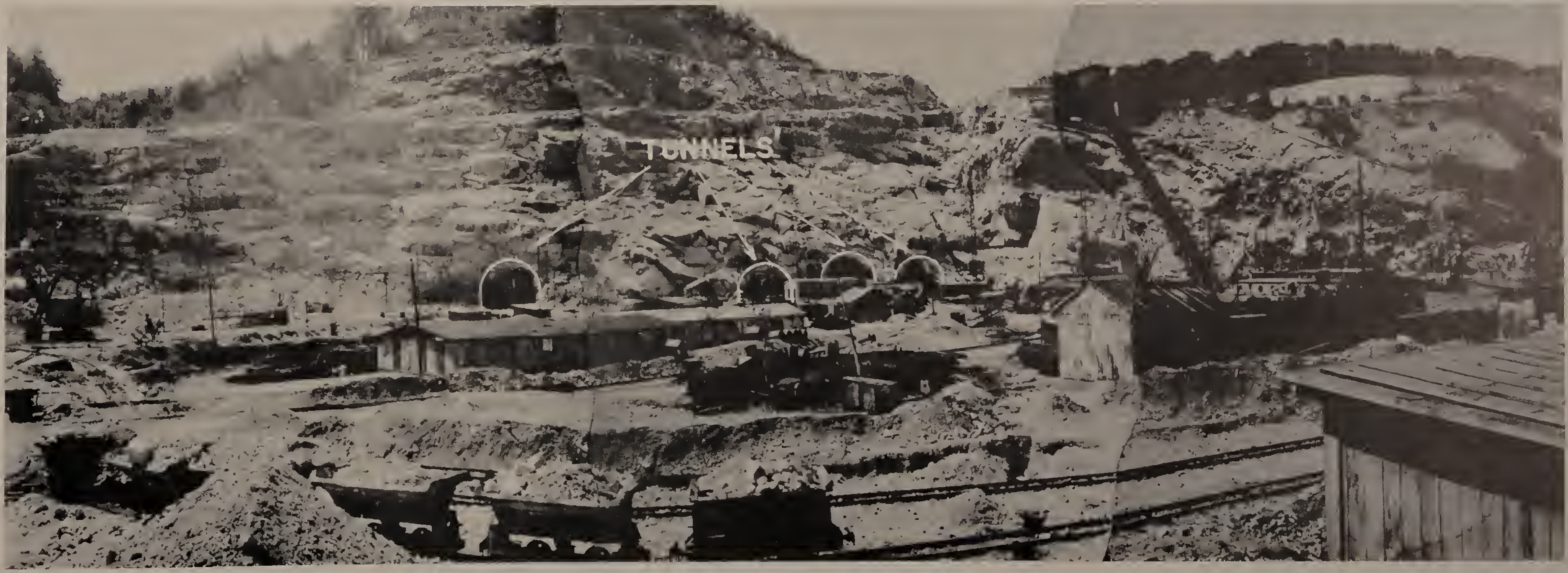


FIGURE 44. Temporary contractors buildings opposite the entrances to an underground liquid oxygen plant under construction at the end of World War II at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. These buildings were built and used for offices and tool storage.
Photos by CIOS Team 163, May 1945. AF Nos. 276581 and 276585.

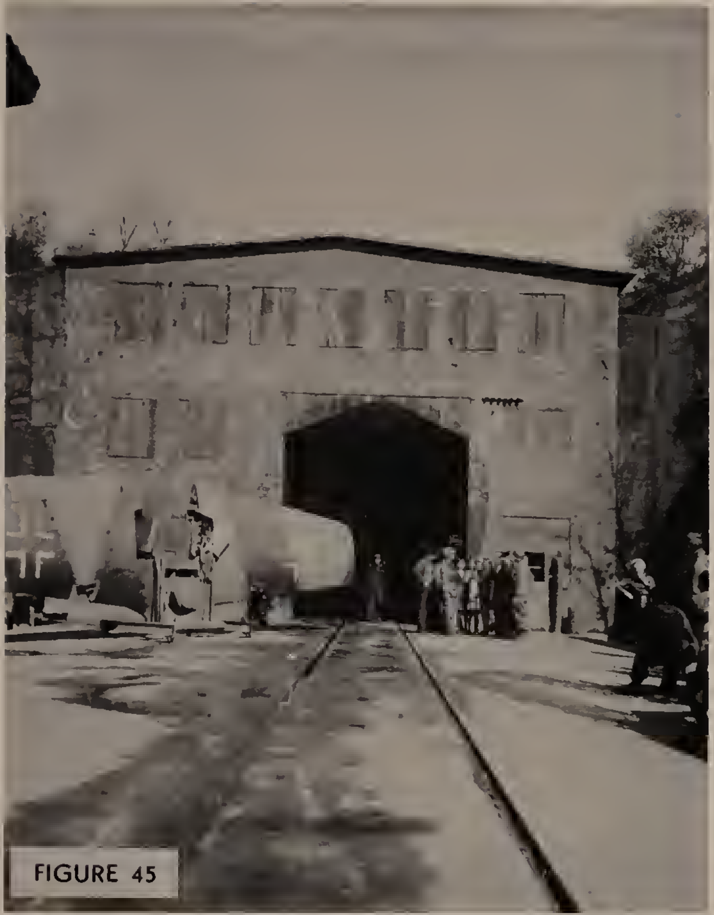


FIGURE 45

FIGURE 45. New building constructed as extension of a railway tunnel which was used for housing an underground factory. Located at Fusa-Schwelm, Germany.

U. S. Army Photo No. ETO–HQ–45–32765, dated 16 April 1945.

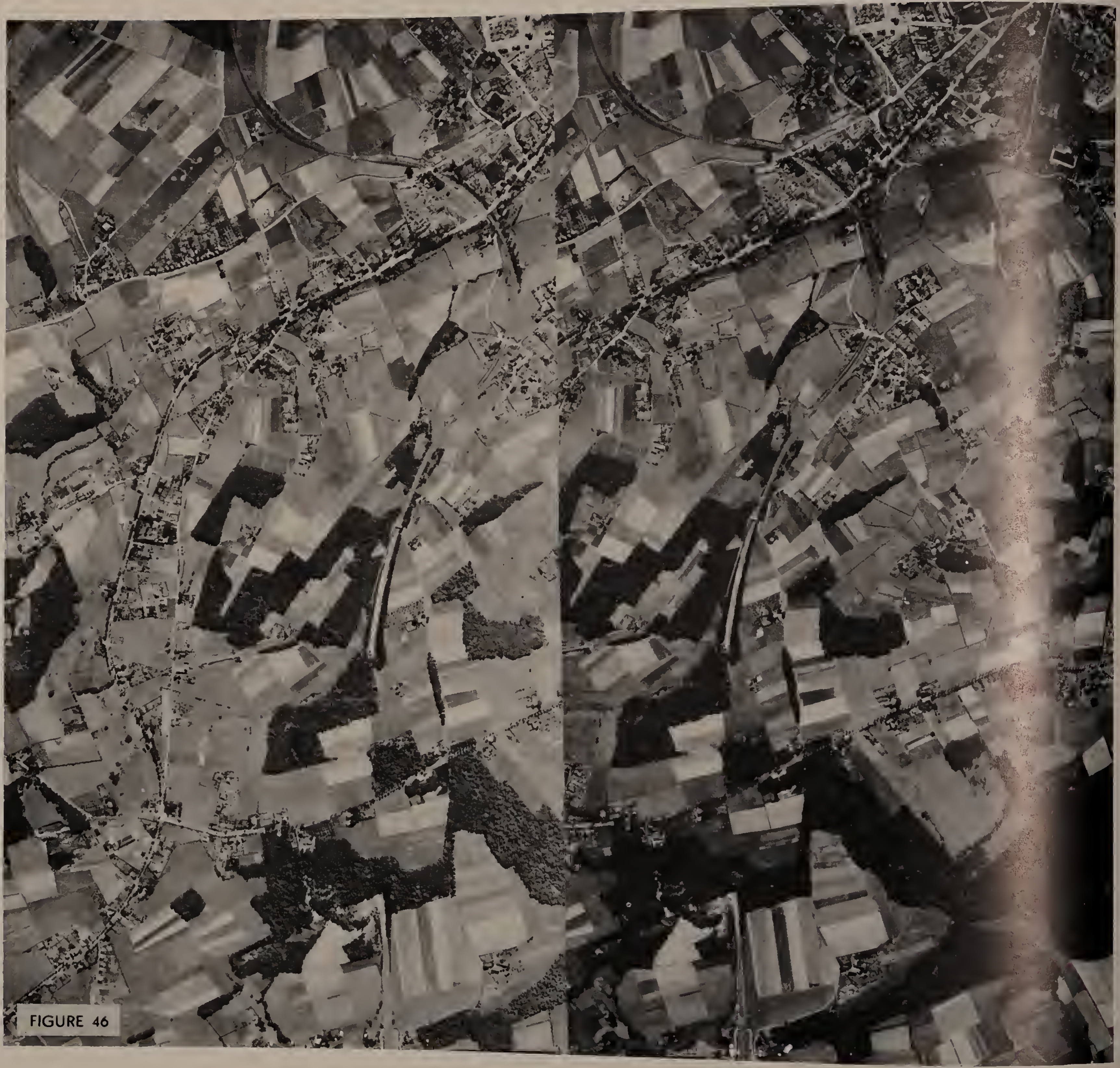


FIGURE 46

FIGURE 46. Buildings constructed at and near entrances to railway tunnel utilized for manufacture of jet aircraft components. Located at Bruch, approximately three miles NE of Wuppertal, British Zone, Germany.

Cover: Prints 3237–3238 of Sortie 106G/LIB, 303, dated 3 Sept. 1945.

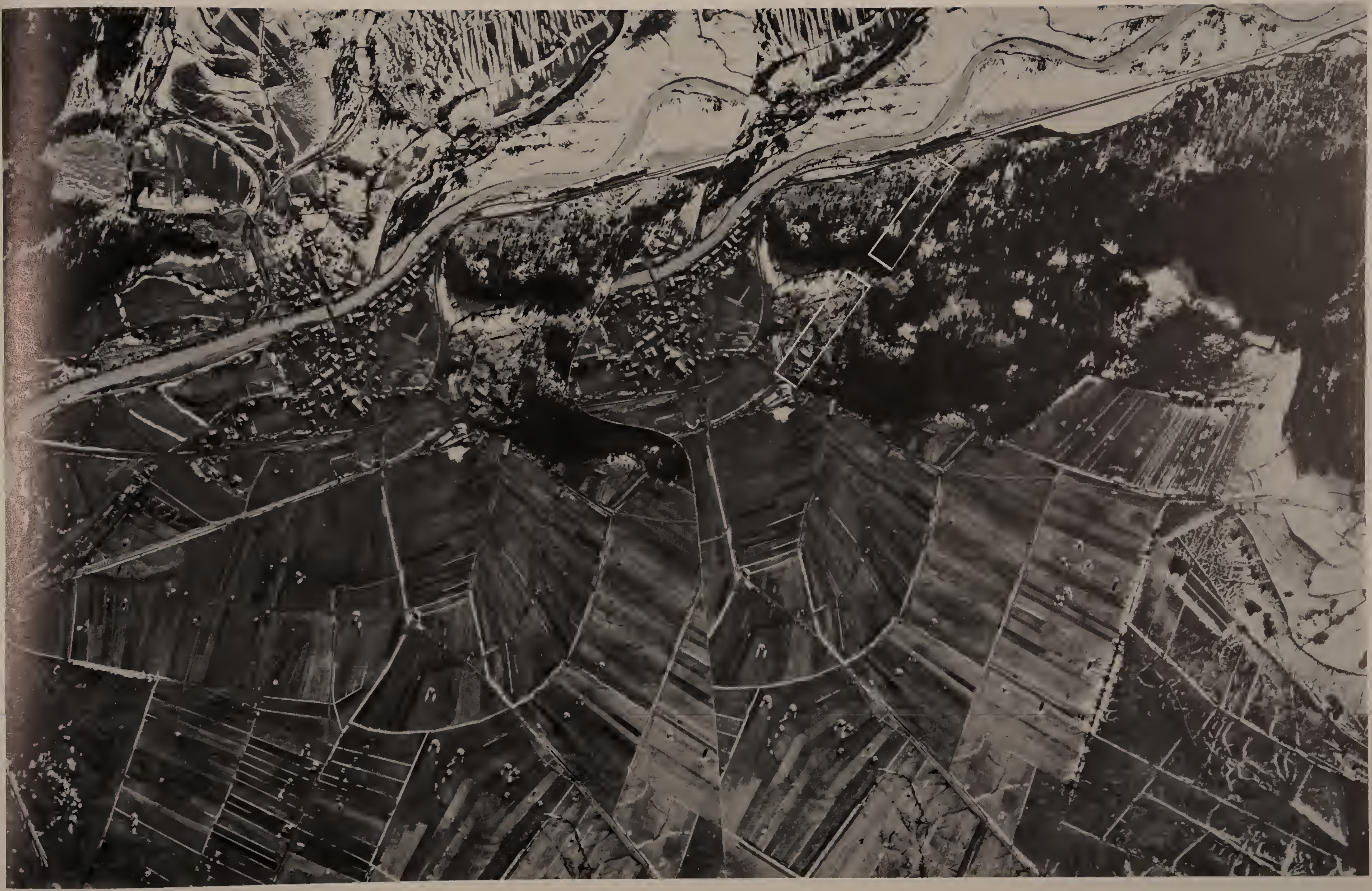


FIGURE 47. Two road tunnels extended by reinforced concrete buildings constructed at the tunnel entrances. The tunnels themselves did not provide sufficient floor space for the entire factory, which produced parts for the Me 262 jet aircraft. This site is 42 miles south of Munich at Eschenlohe, U. S. Zone, Germany.

The construction of above ground labor camps at German underground factories was a common occurrence in World War II. These labor camps, also known as hutted camps, were frequently dispersed in woods and in valleys. As many as six camps were built at some sites and some of the camps were as far as two miles away from the underground sites. They were more common and more numerous at newly excavated sites which usually were located out in the country where housing facilities were either inadequate or lacking. Housing in villages and towns was utilized for production workers, usually nonprison labor, when available. At some underground factories housing had to be provided for as many as 10,000 workers. The camp buildings were the wooden barrack types, mostly one story and of several sizes. Some were prefabricated.

The photo interpretation of these labor camps was easy because they were not only set apart from the local dwellings but the arrangement of the buildings and the type of architecture did not conform to the pre-existing pattern. The buildings were seldom arranged in an orderly manner. Many of the camps were enclosed by a high wire fence because prison labor was commonly used for the excavation and construction work. Guard towers spaced at regular intervals along these fences were also a common feature. A smaller group of barracks for the guards was frequently located outside the fence and near the main entrance to the camp.

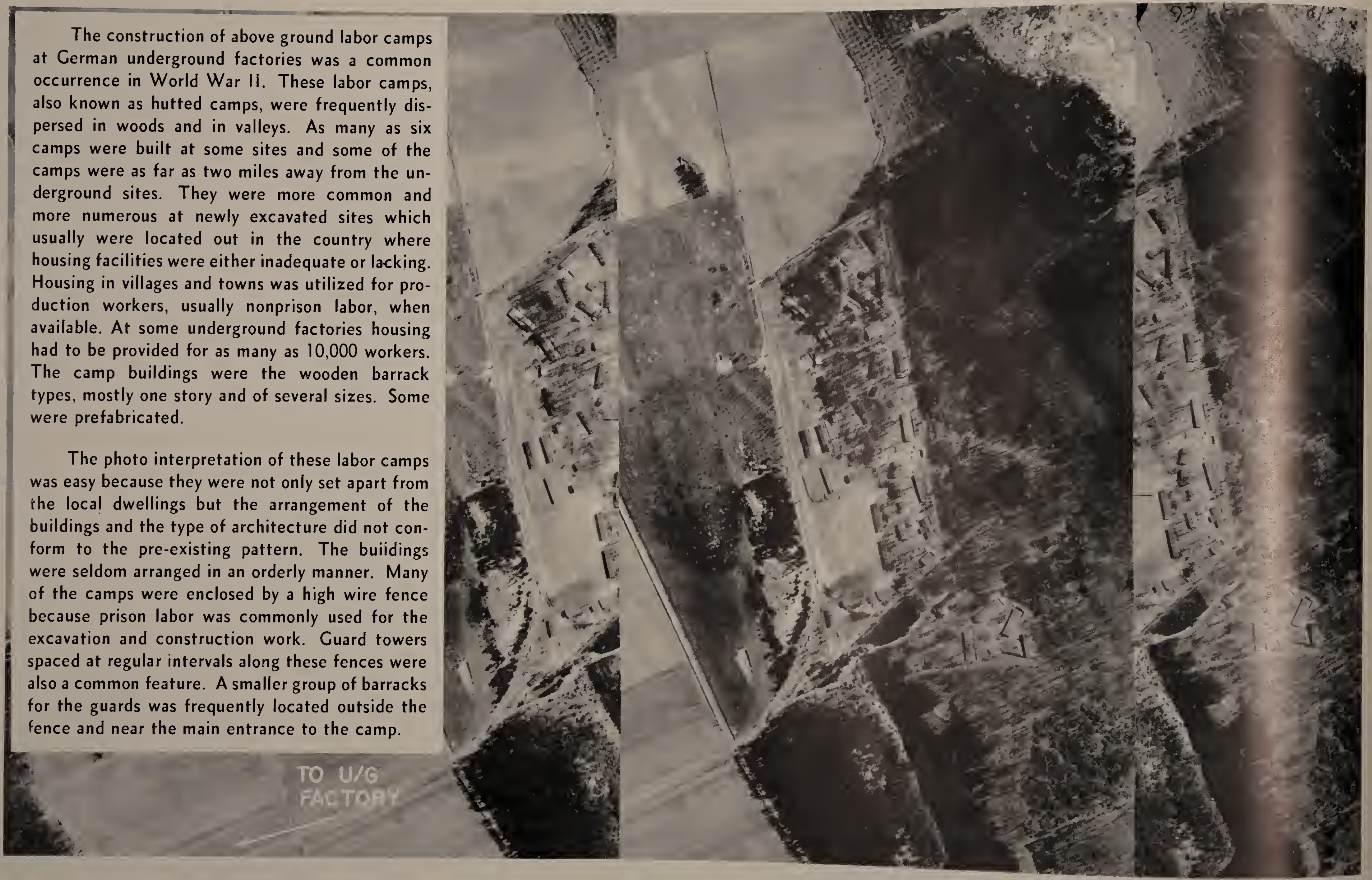


FIGURE 48. Labor camp for construction workers at a Junkers underground factory, Langenstein, Soviet Zone, Germany. The factory is not shown in these photographs.

Cover: Prints 4240–4242 of Sortie 106G/5056, dated 23 March 1945.

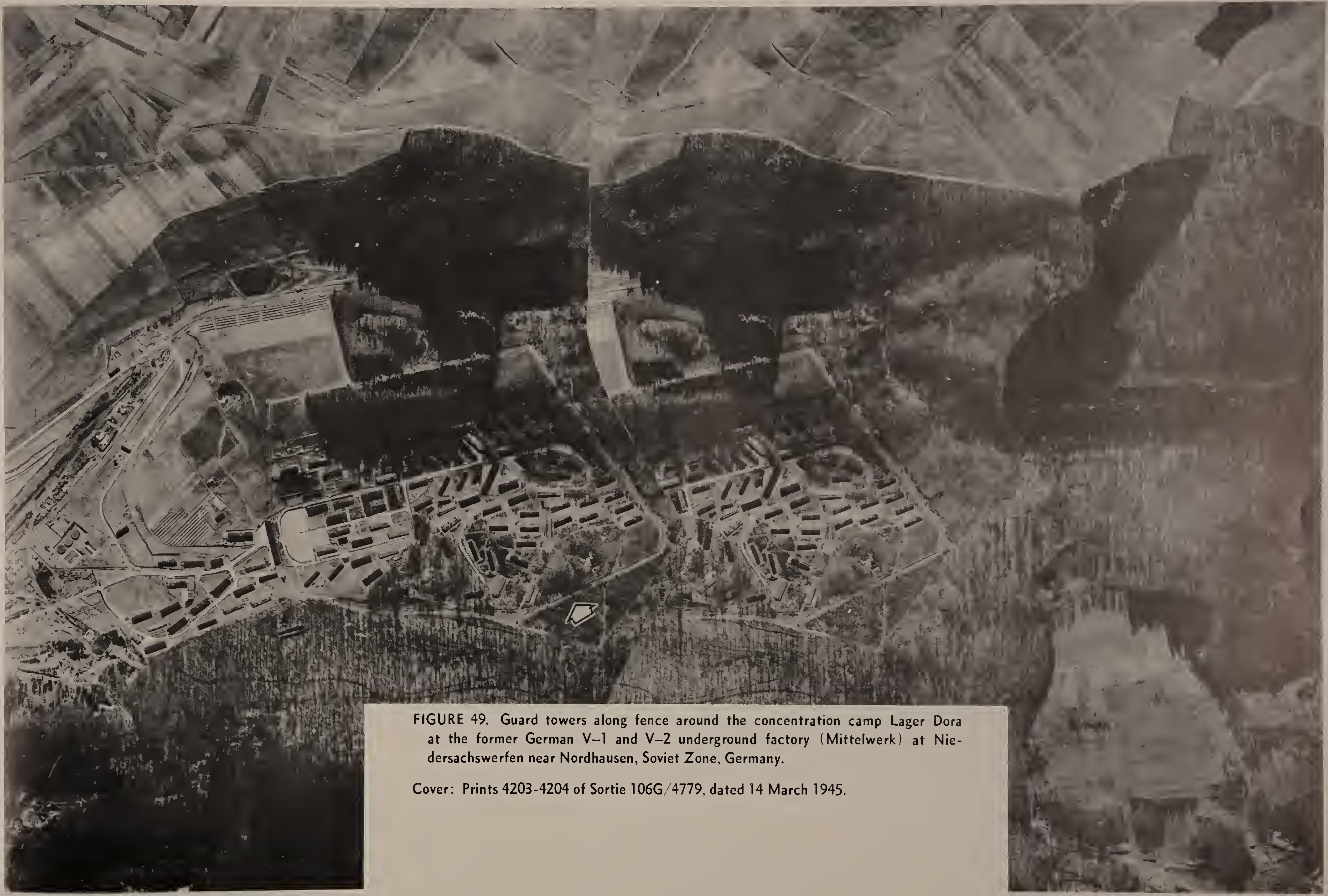


FIGURE 49. Guard towers along fence around the concentration camp Lager Dora at the former German V–1 and V–2 underground factory (Mittelwerk) at Niedersachswerfen near Nordhausen, Soviet Zone, Germany.

Cover: Prints 4203-4204 of Sortie 106G/4779, dated 14 March 1945.

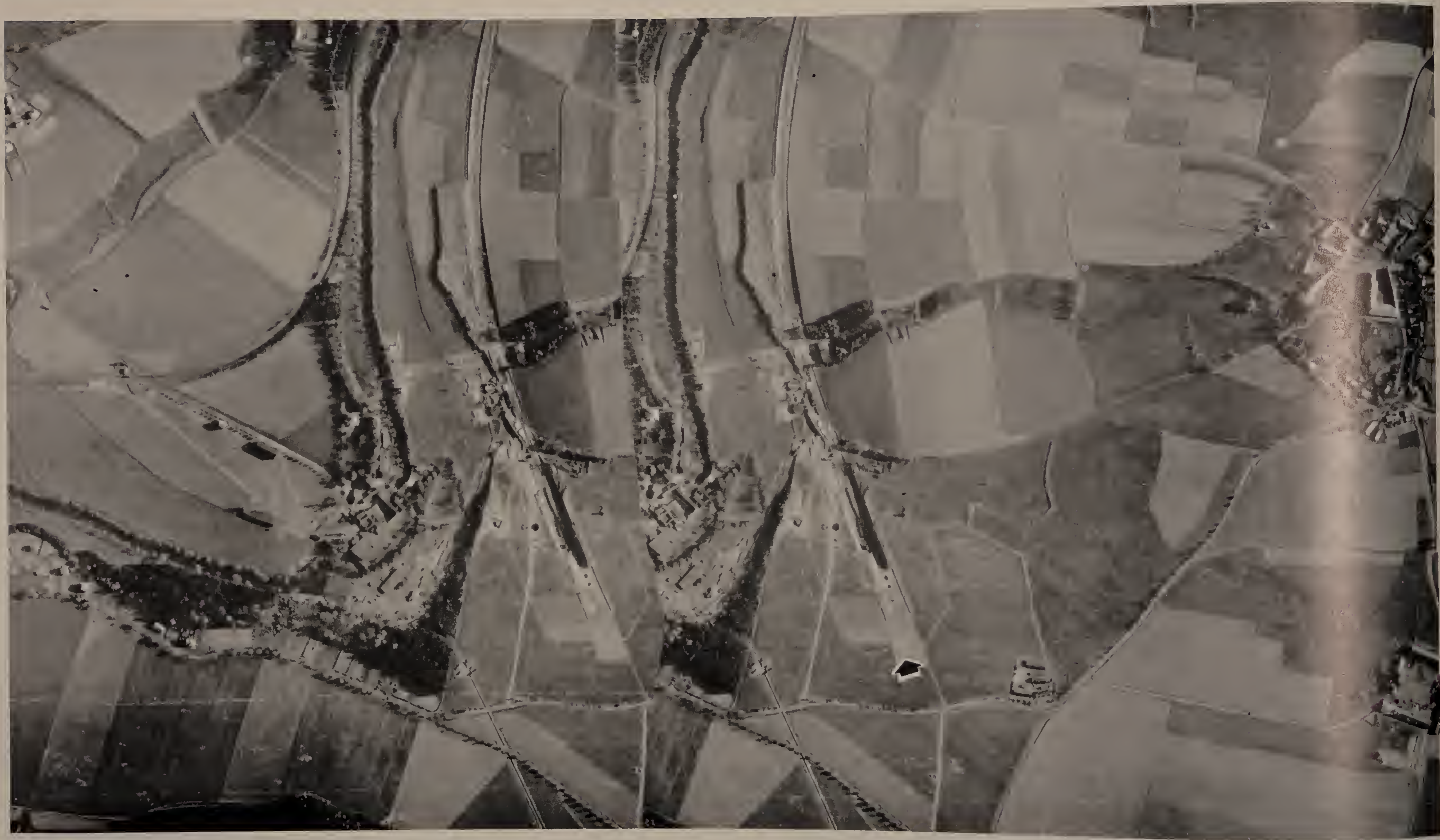


FIGURE 50. Protective wire fence under construction around entrance to underground lubricating oil plant in a railway tunnel at Deutsch-Brod (Nemecky), Bohemia, Czechoslovakia. The installation of the plant in the tunnel was not completed and no production was obtained.

Cover: Prints 3207–3208 of Sortie 104 W, C.173, dated 4 May 1945.

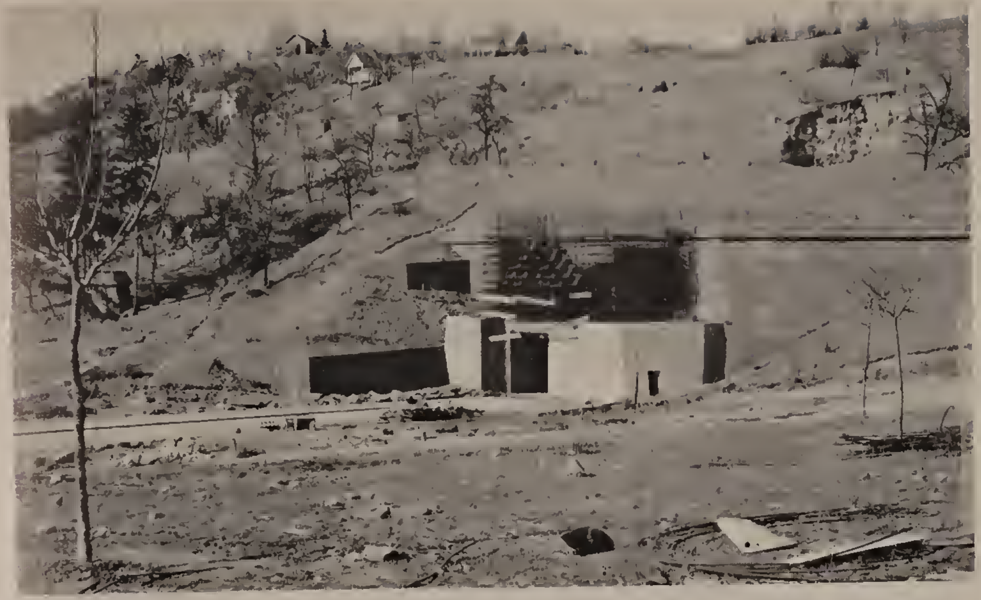


FIGURE 51. Reinforced concrete construction at one of four entrances to a Messerschmitt factory in twin autobahn tunnels at Leonberg, U. S. Zone, Germany. The reinforced entrance was being built to give protection against skip-bombing. Heavy doors were to have been installed. The small door at the side was a personnel entrance. This underground factory produced wings for the Me 262 jet fighter. Photo by A–2, USAFE, 1946.

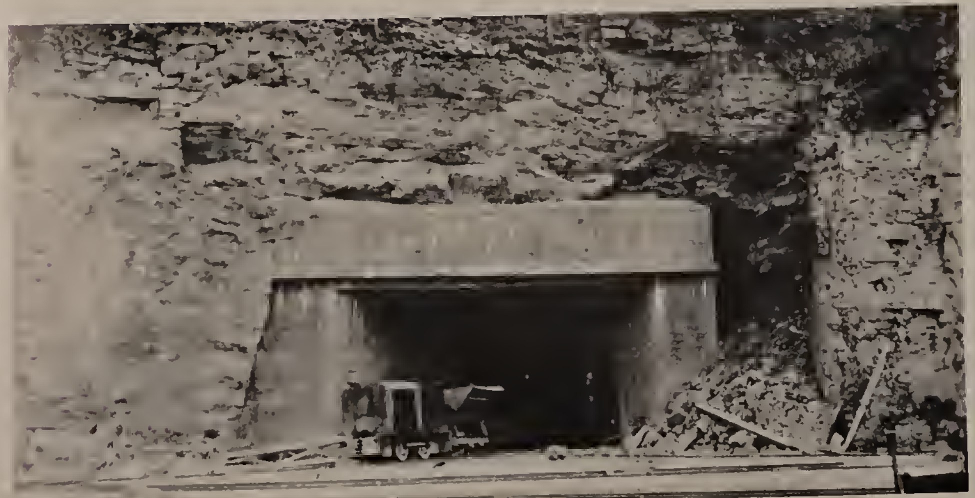


FIGURE 52. Brick and concrete reinforcement at Entrance No. 4 to Kugelfischer underground ball and roller bearing factory in a limestone mine at Wellen, French Zone, Germany. There are three levels to this mine, all of which were to have been used. Entrance No. 4 was on the middle level. Production was just about to begin when the factory had to be dismantled and evacuated because of the approach of Allied troops. Photo by British Bombing Survey Unit, Team No. 42, 1946. AF Neg. No. 276583.

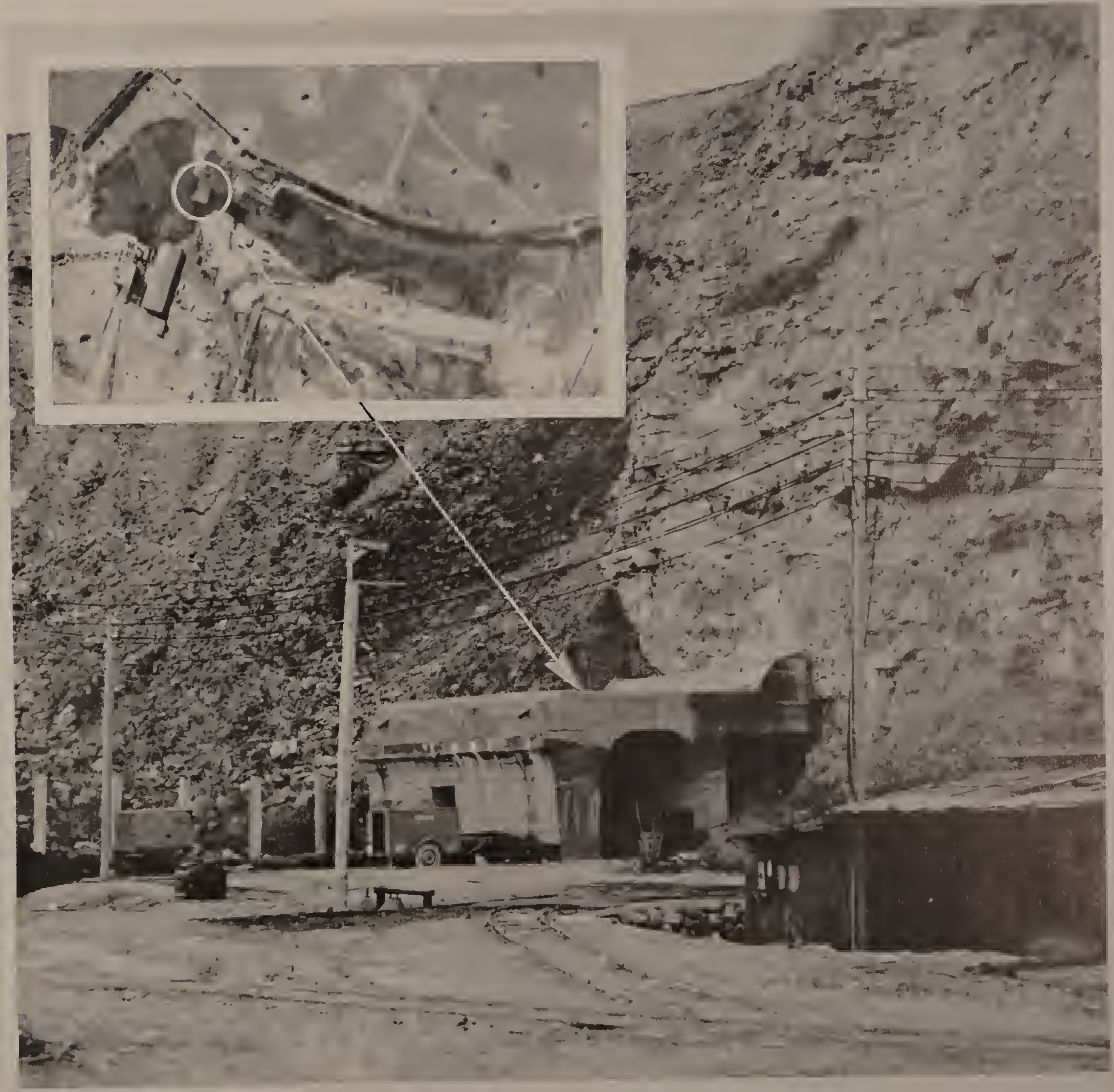


FIGURE 53. Concrete canopy-like structure at Entrance No. 1 to M.A.N. underground factory at Weisenau, French Zone, Germany. This structure was designed to protect the interior of the plant against the blast effect of bombs falling near the entrance. Sliding steel doors were to have been installed. This underground factory was in newly excavated tunnels, had six entrances and produced launching tubes for the V–1 flying bomb. Photo by A–2, USAFE, 1946. An aerial view of the canopy-like structure is shown in the inset. Print 4037 of Sortie 106G/4595, dated 2 March 1945.

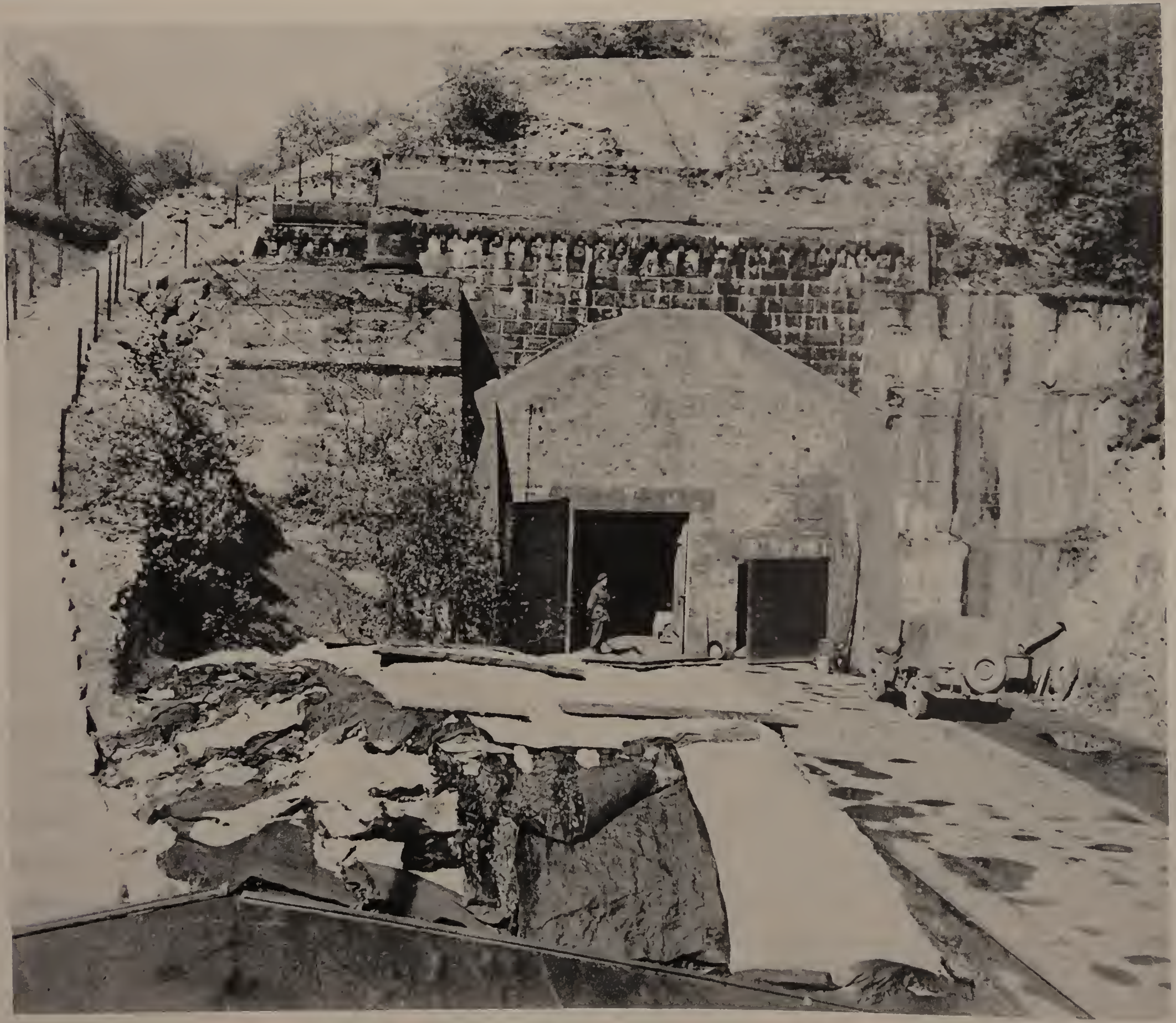


FIGURE 54. Heavy wooden doors and brick wall at entrance to an underground factory in a railway tunnel at Lengerich, British Zone, Germany. This factory, which produced aircraft parts, was operated by the Vereinigte Leichtmetallwerke of Hannover.

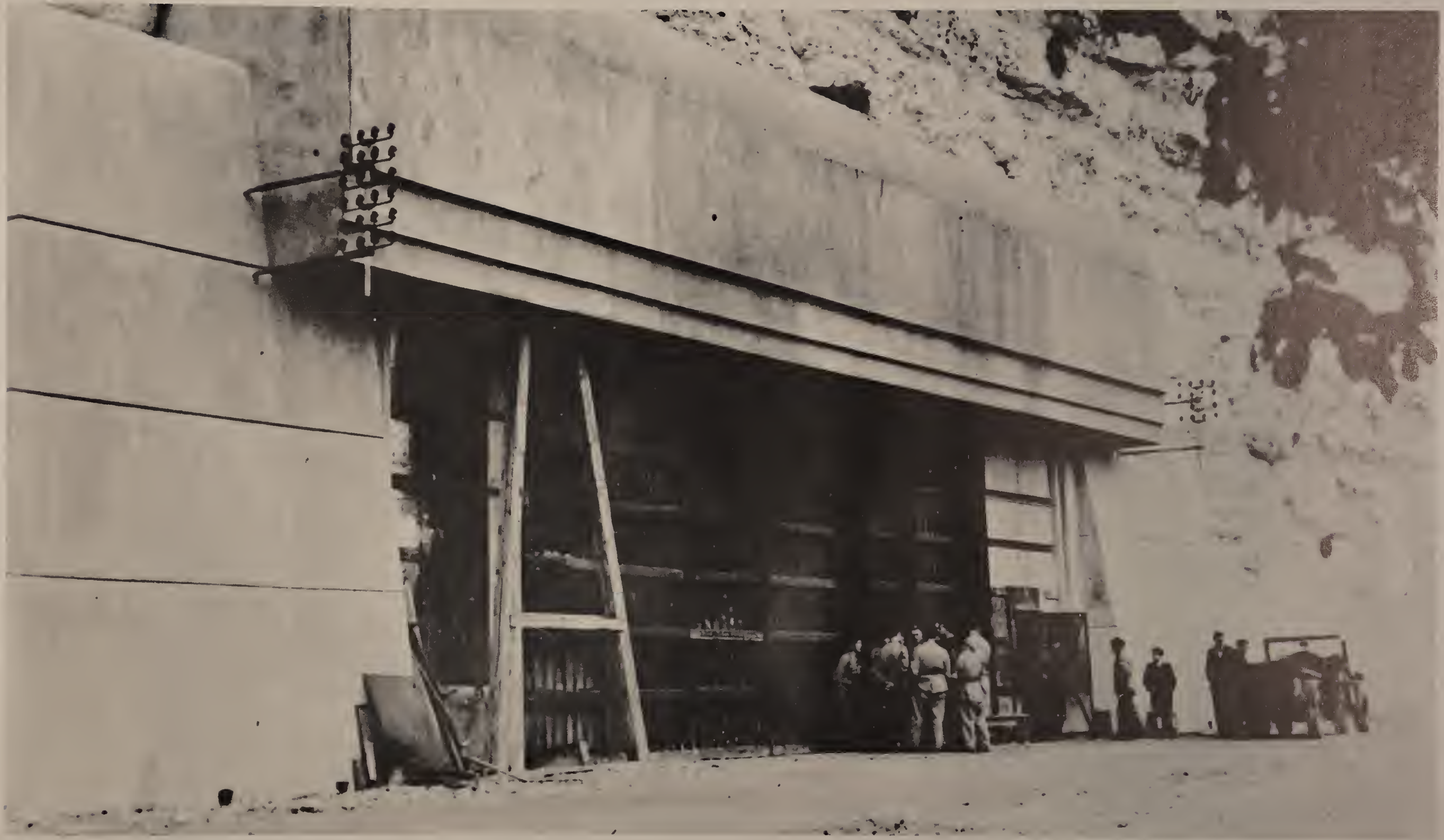


FIGURE 55. Protective construction at entrance to an underground aircraft factory at St. Astier, France. This factory was located in a limestone mine and had 500,000 sq. ft. of floor space, its own power and lighting plant, a modern kitchen and dining room, and air conditioning. During the war it produced FW 190 fuselages. After the war the French began retooling the factory for the production of four engine commercial aircraft. USSTAF Photo 1944. AF Neg. No. A–55035 A.C.

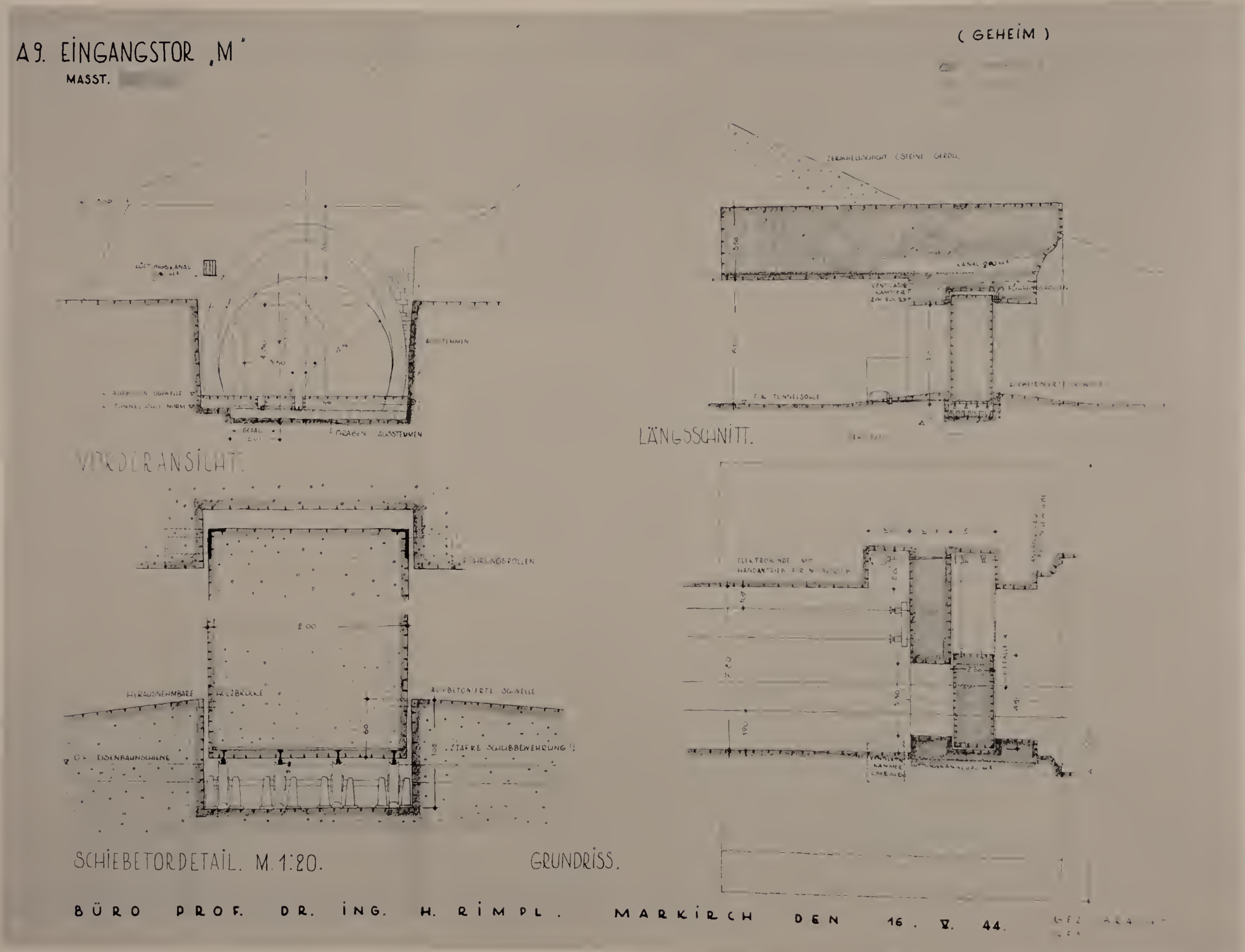


FIGURE 56. Captured German drawings of a concrete floor designed for the entrance to a BMW underground factory in a railway tunnel at Markirch, France. Similar doors were installed in a Bosch underground factory in a railway tunnel at Bruttig, French Zone, Germany. The Germans planned to install bomb proof doors at the entrances to many of their underground factories. The designs and thicknesses varied. Some doors were suspended from the top rather than supported by rollers at the bottom. Plans were underway for gas-proof doors.

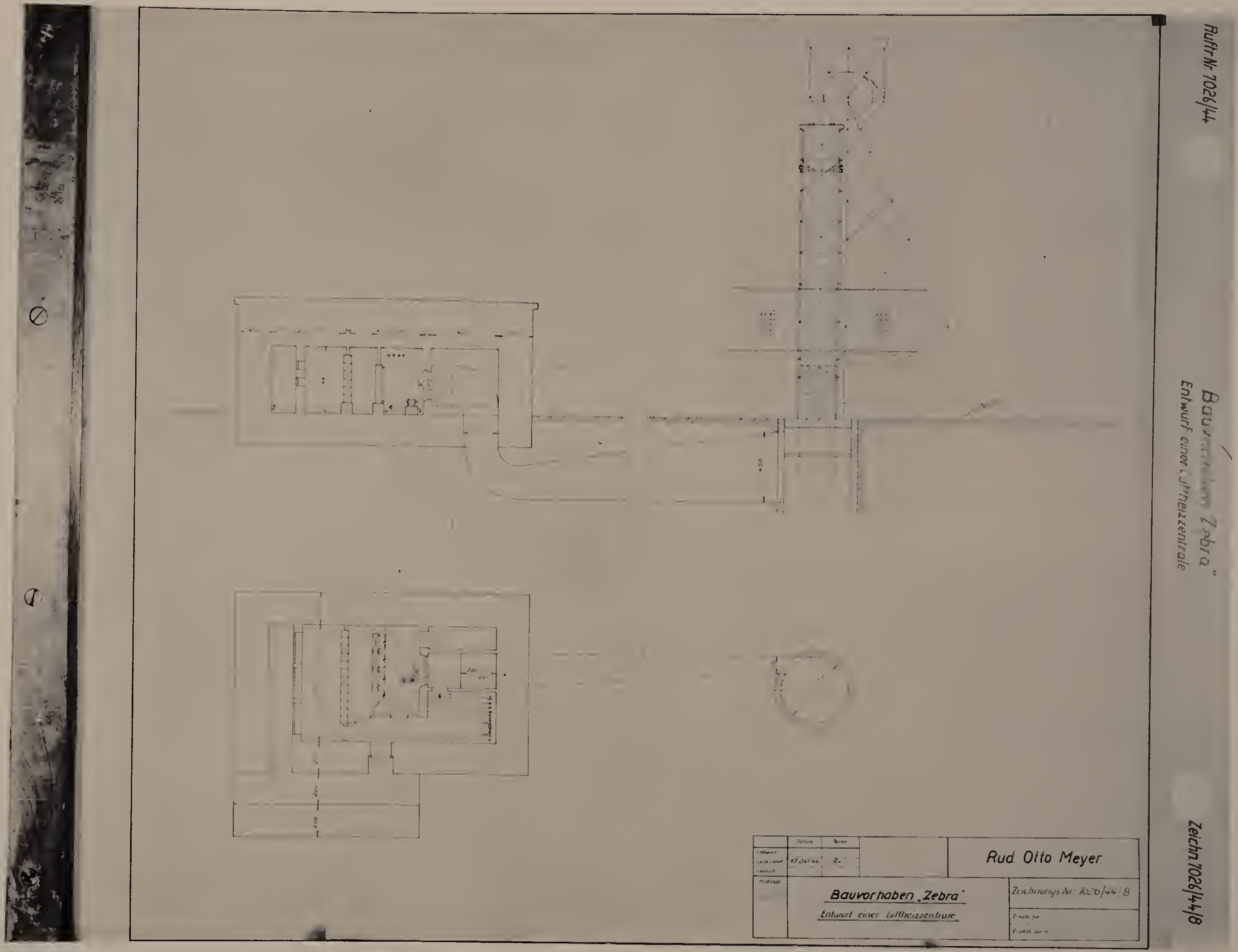


FIGURE 57. German drawings of bomb resistant concrete building for housing a central air heating plant for an underground aircraft factory in a salt mine at Stassfurt, Soviet Zone, Germany. This plant also can be used for cooling the air by circulating cold water through the radiators. Note that the walls of the building are two meters thick and that the entrances are protected by a blast wall.

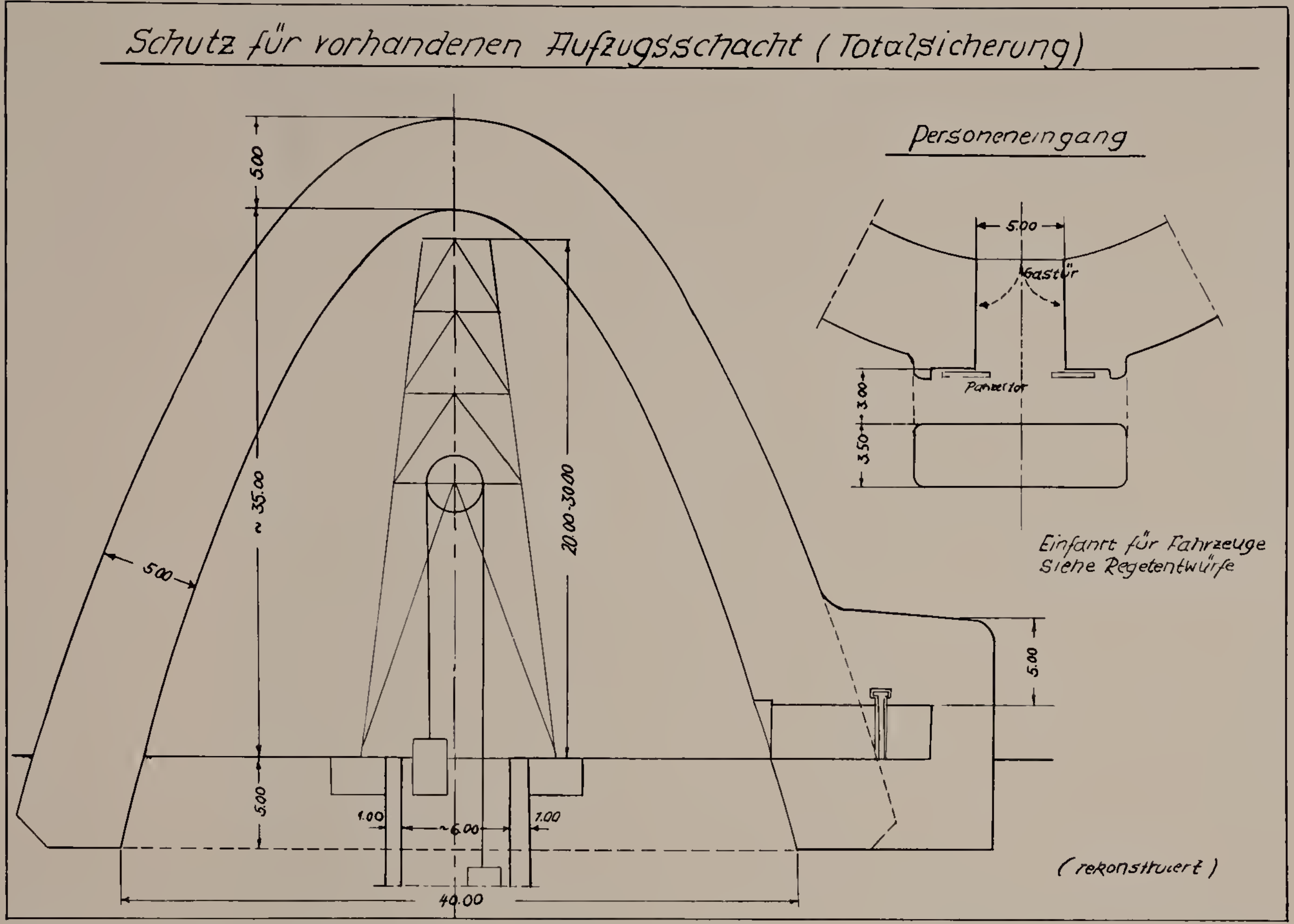


FIGURE 58. German drawing of a concrete shelter designed to give maximum protection to an already existing shaft house over the entrance to a vertical shaft mine. There are approximately 220 salt mines of this type in Germany. Many of these were used for housing underground factories and storage depots in World War II. Some of the aircraft factories in these mines were producing fuselages and wings for fighter aircraft. However, even though these mines provided millions of square feet of already usable floor space and had from 1,000 to 2,000 feet of overburden, the entrances to them were vulnerable to bombing. Most of these salt mines had only one or two entrances. The above drawing is an example of only one of many schemes the Germans had for protecting the entrances to these underground installations. Another scheme envisaged the excavation of a new sloping shaft which would connect with the old vertical shaft a few hundred feet below the surface. This was coupled with the construction of a reinforced concrete shaft house built below the level of the ground and covered by a thick concrete slab which was to be either flush with the grounds or extend only a few feet above it. It is not known if any of these protective construction schemes were actually completed. Such structures should be clearly visible on aerial photographs and should be susceptible to interpretation. Note that the structure shown above would have been a hollow cone 16.4 feet thick and 131.2 feet high. Note also that the entrance to it was to be protected by a blast wall and two sets of doors, one of which was to be gas proof.

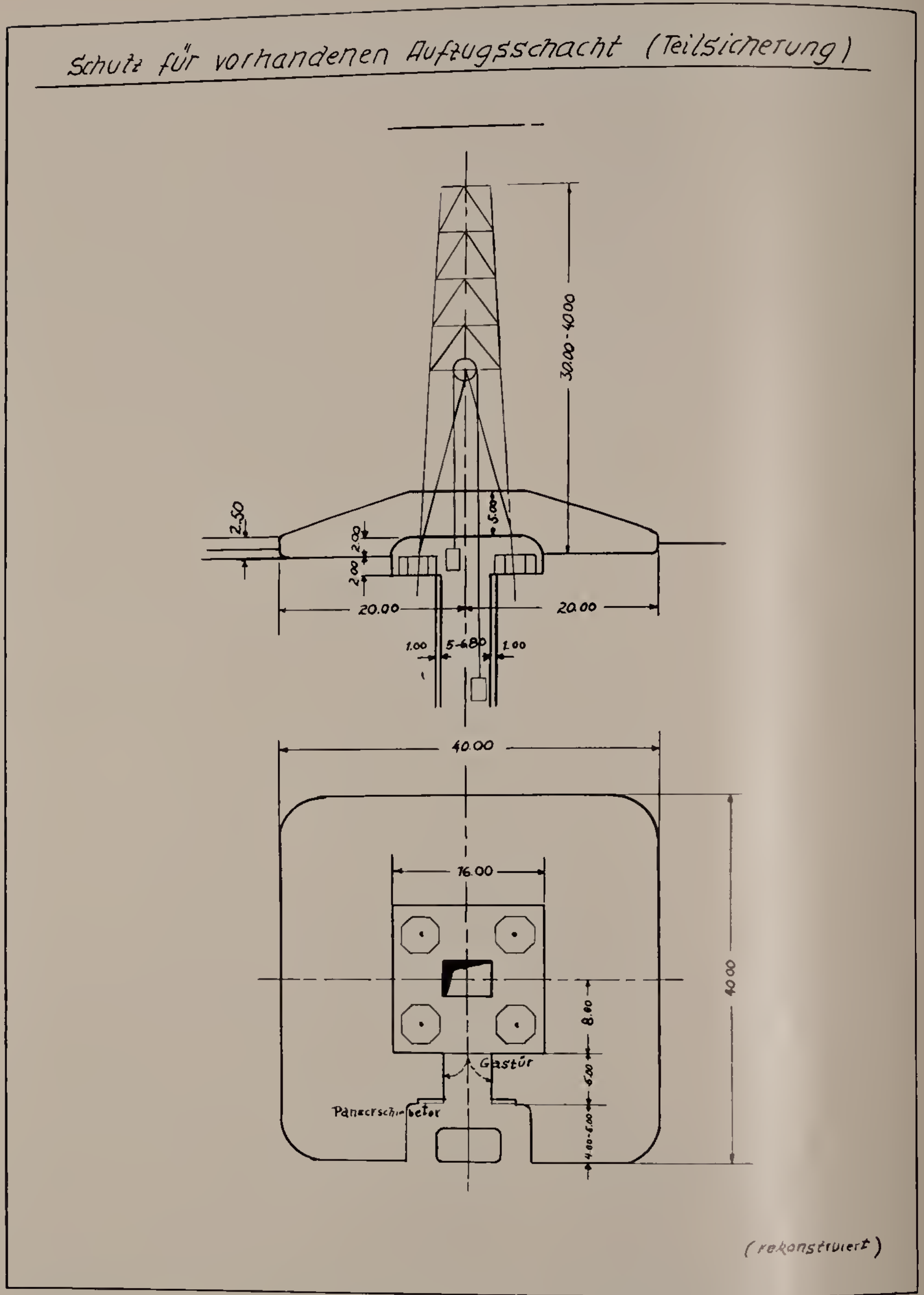


FIGURE 59. German drawing of concrete slab designed partially to protect the entrance to the shaft of an already existing shaft mine. This would give some protection against caving in of the shaft but give no protection to the shaft house. The dimensions are in meters. Note that the slab was to be 16.4 feet thick in the center.

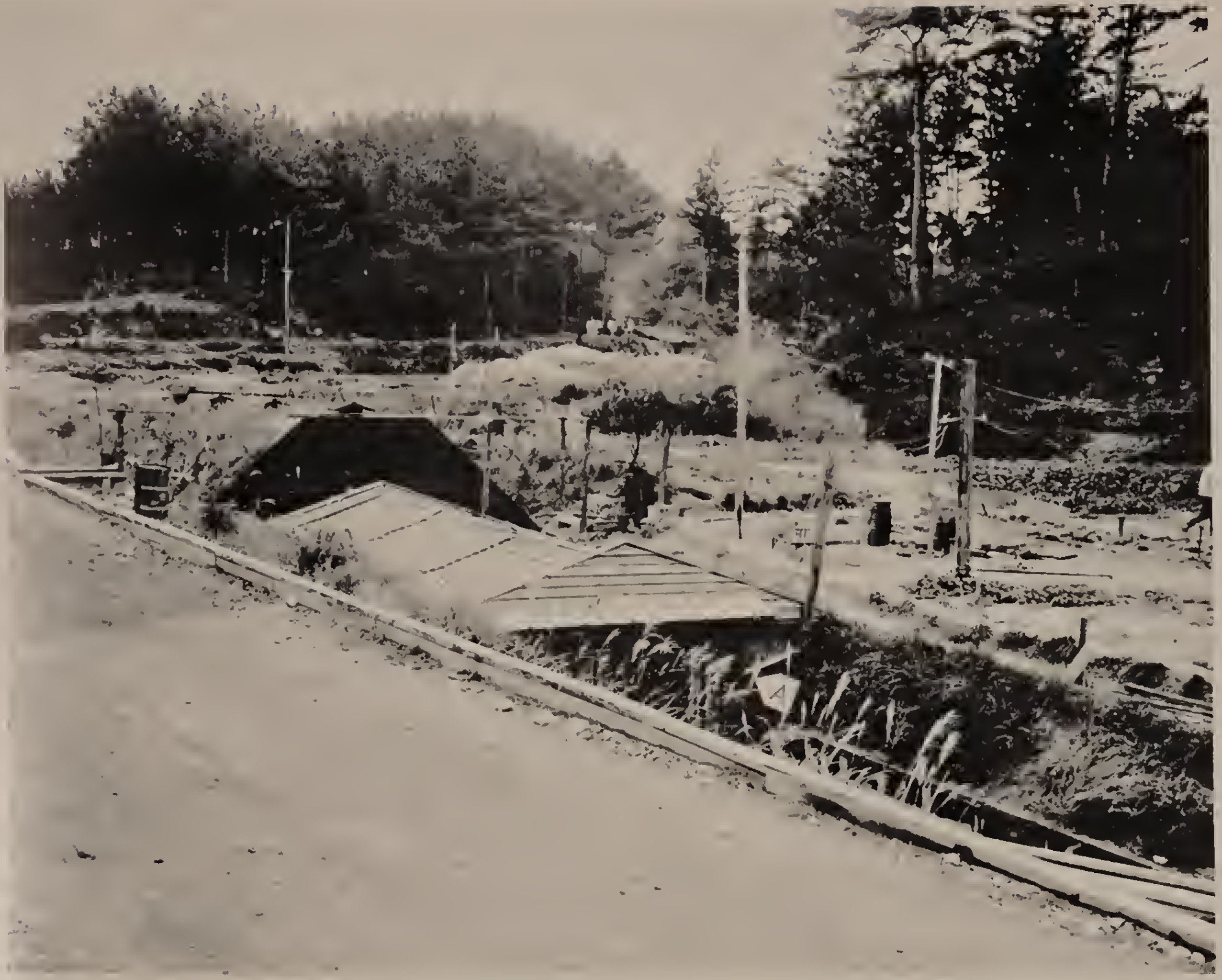


FIGURE 60. Entrance to tunnel A at Mitsubishi underground aircraft parts factory southwest of Nagoya at Hisai, Japan. Note that the entrance was concealed by buildings erected in the approach cut. An aerial view of this entrance is shown in Figure 61. This underground factory had at least six entrances and was located in tunnels which had been excavated to obtain sand for abrasives. The other entrances were also concealed by similar buildings. The existence of the approach cut is suggestive of a tunnel entrance but its location on fairly flat ground is uncommon. Therefore, the concealment of the entrance by buildings in the cut was more effective than would have been the case had the cut been in sloping ground or in a steep hillside. Also, the construction of semi-underground buildings was common practice in Japan during World War II. Photo by U. S. Strategic Bombing Survey.

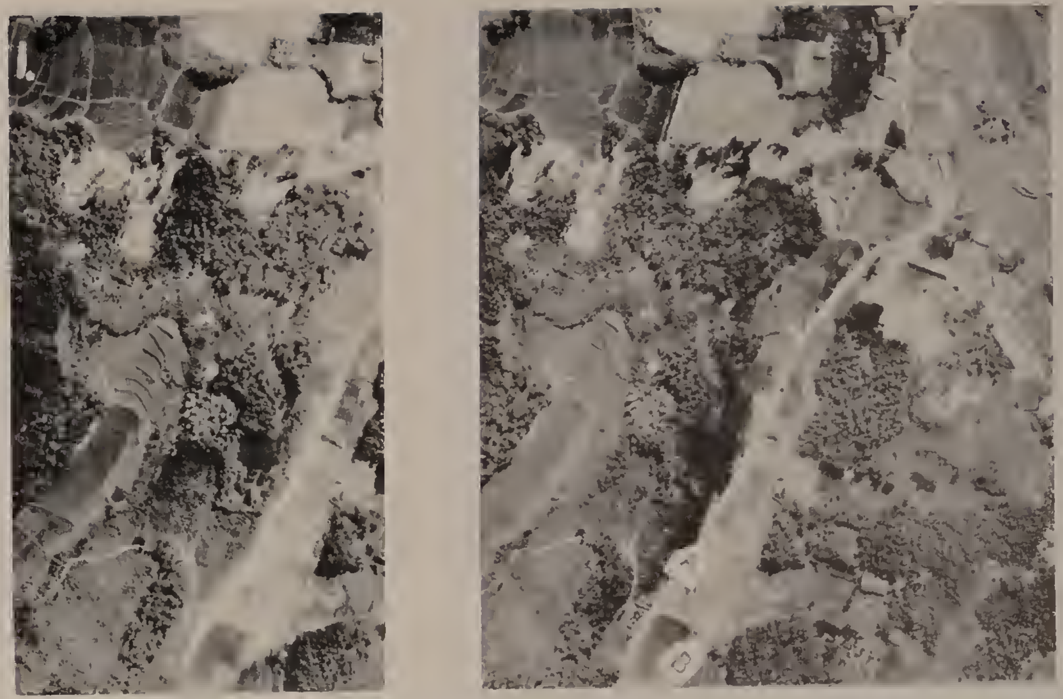


FIGURE 61. Stereogram of concealed tunnel entrance at Hisai, Japan, shown in Fig. 60. The buildings which conceal the entrance to tunnel B are also shown.

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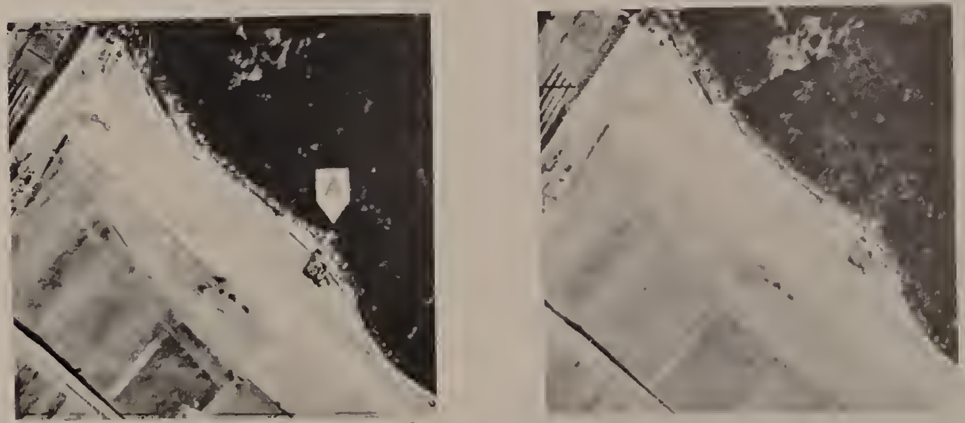


FIGURE 62. Camouflage of spoil at the Junkers underground jet engine components factory at Langenstein near Halberstadt, Soviet Zone, Germany. The sandstone, which was as unconsolidated as sand when excavated, was spread out evenly on the ground, covered with soil and then planted in grass. A tunnel entrance and a transshipment station for narrow gauge railway dump cars is shown at A. Stereo pair from Special Report by CIOS Team 163, dated 2 September 1945. ACIU Neg. No. 58902.

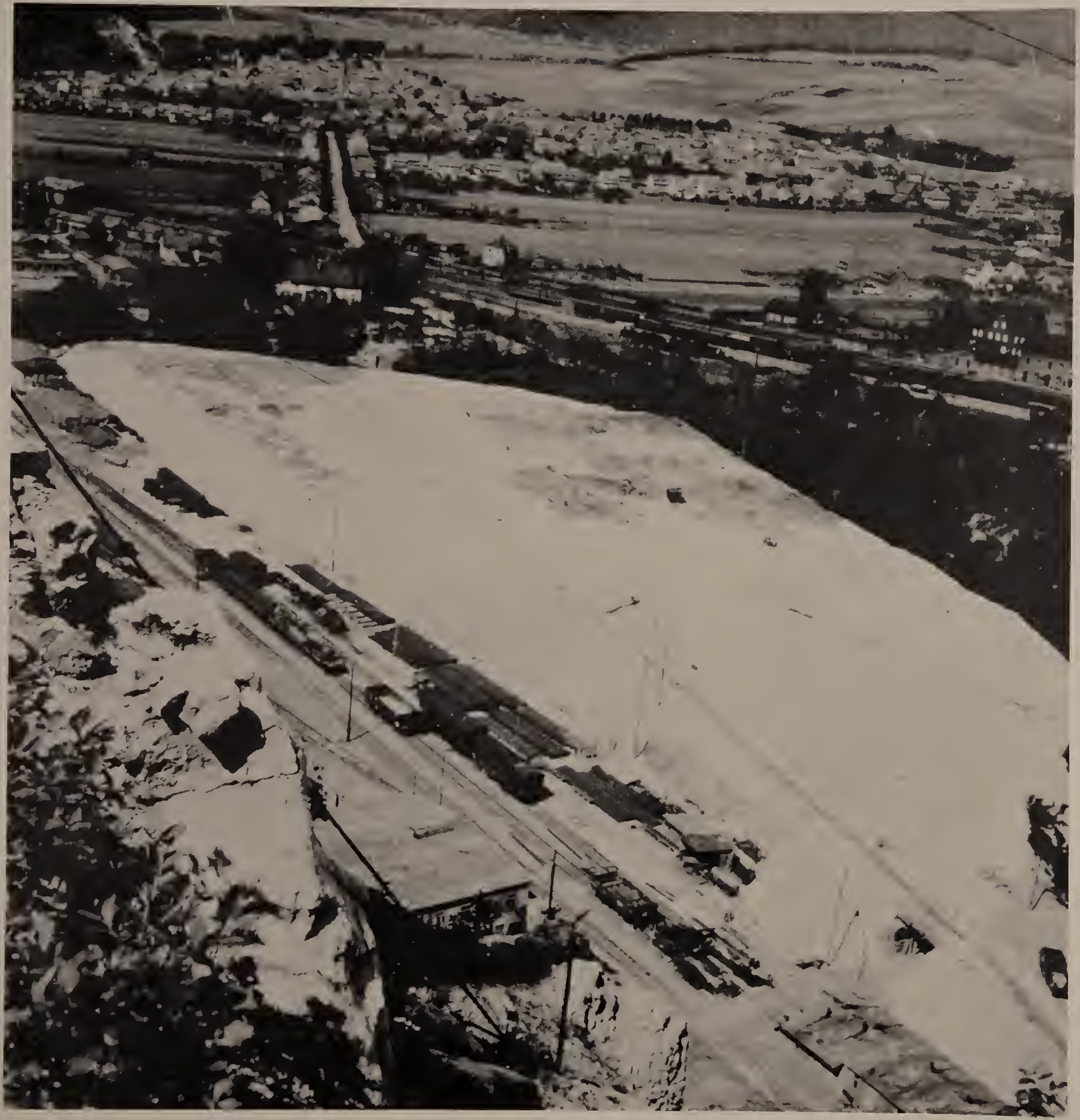


FIGURE 63. Unfinished spray paint camouflage on waste dump of anhydrite opposite new tunnels excavated for an underground synthetic aviation gasoline plant (Kuckuck I) at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. An aerial view of this waste dump is shown in Fig. 64. Photo by CIOS Team 163, May 1945, AF Neg. No. 276580.

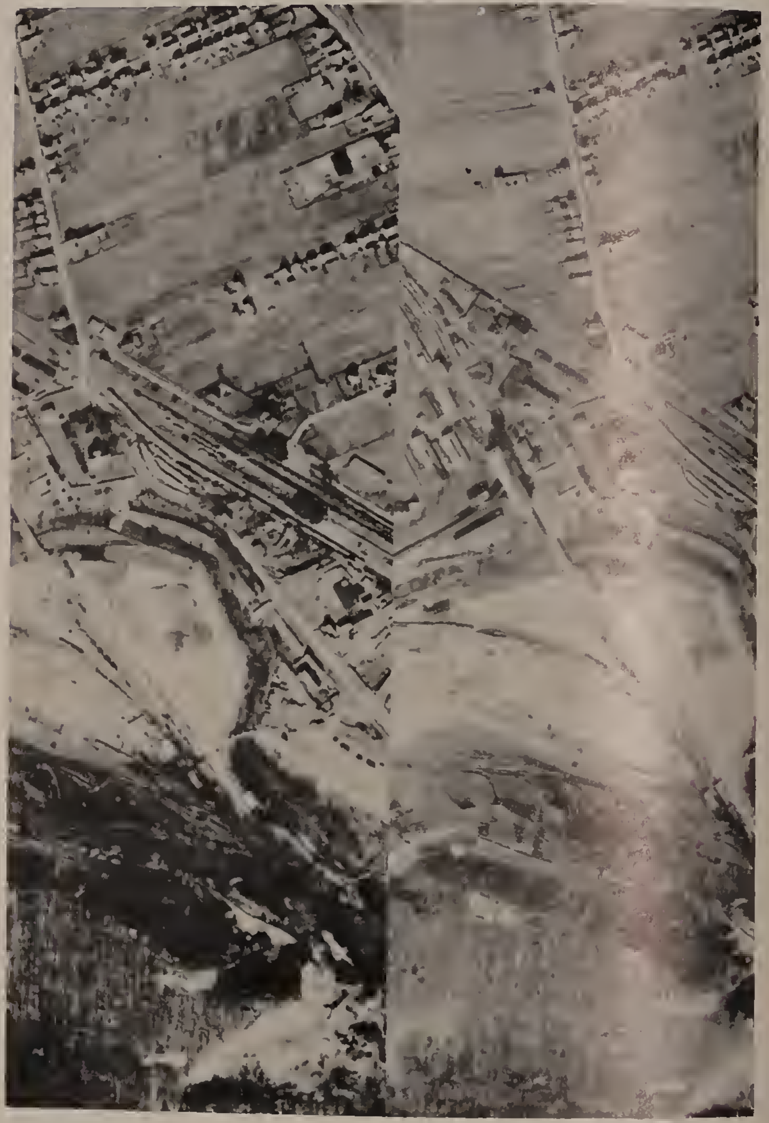


FIGURE 64. Stereogram of camouflaged waste dump at Niedersachswerfen shown in Fig. 63.

Cover: Prints 3205–3206 of Sortie 106G/4779, dated 14 March 1945.

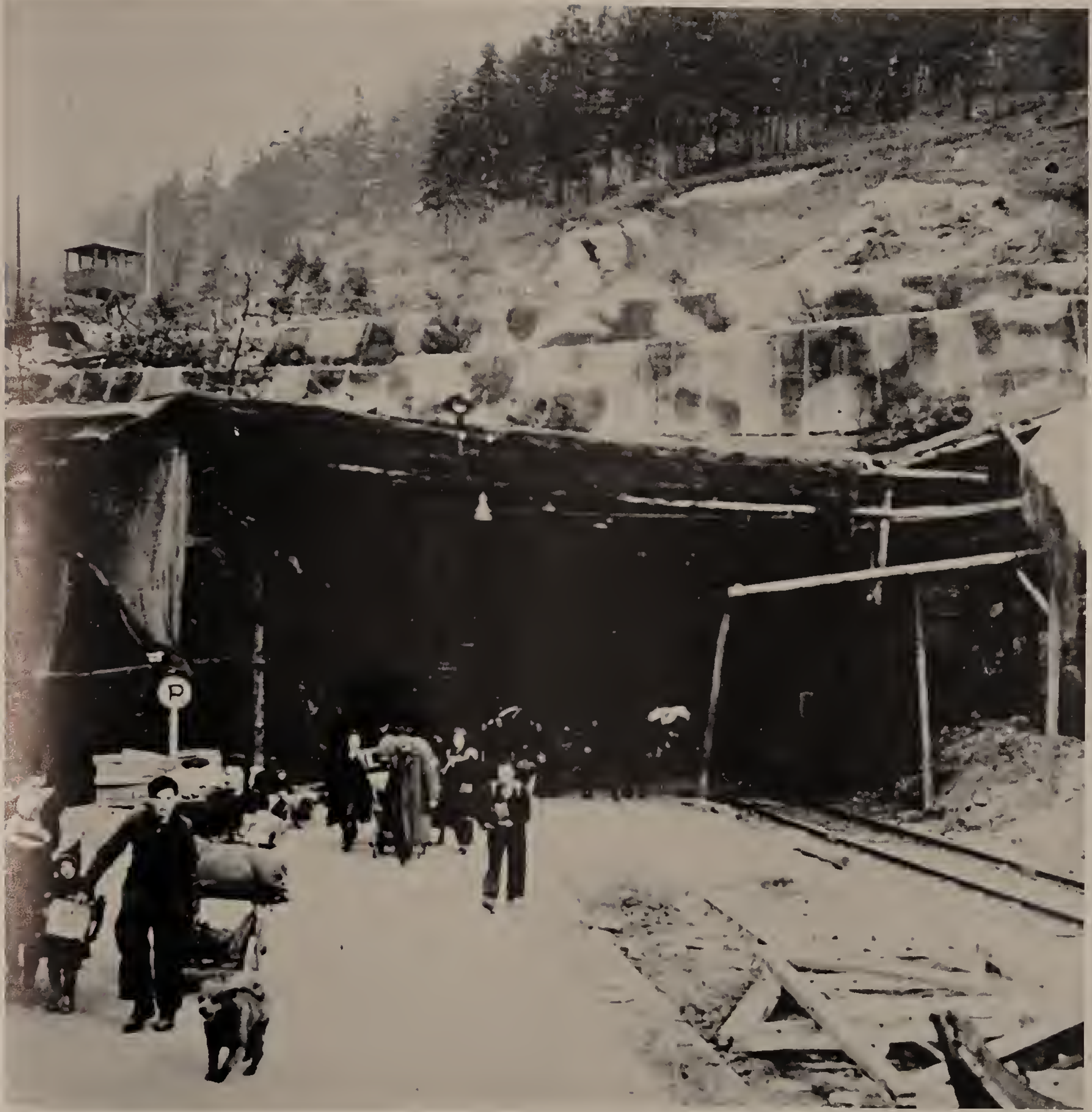


FIGURE 65. Camouflage netting supported by wooden framework at Entrance A to underground V–1 and V–2 factory (Mittelwerk) at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. The displaced persons shown in the photograph used the tunnels as an air raid shelter during the chaotic period following the abandonment of the factory by the Germans and before its capture by the Americans. This photograph was taken shortly after the arrival of the American troops. An aerial view of this entrance is shown in Fig. 66. ACIU Copy Neg. No. 58477.

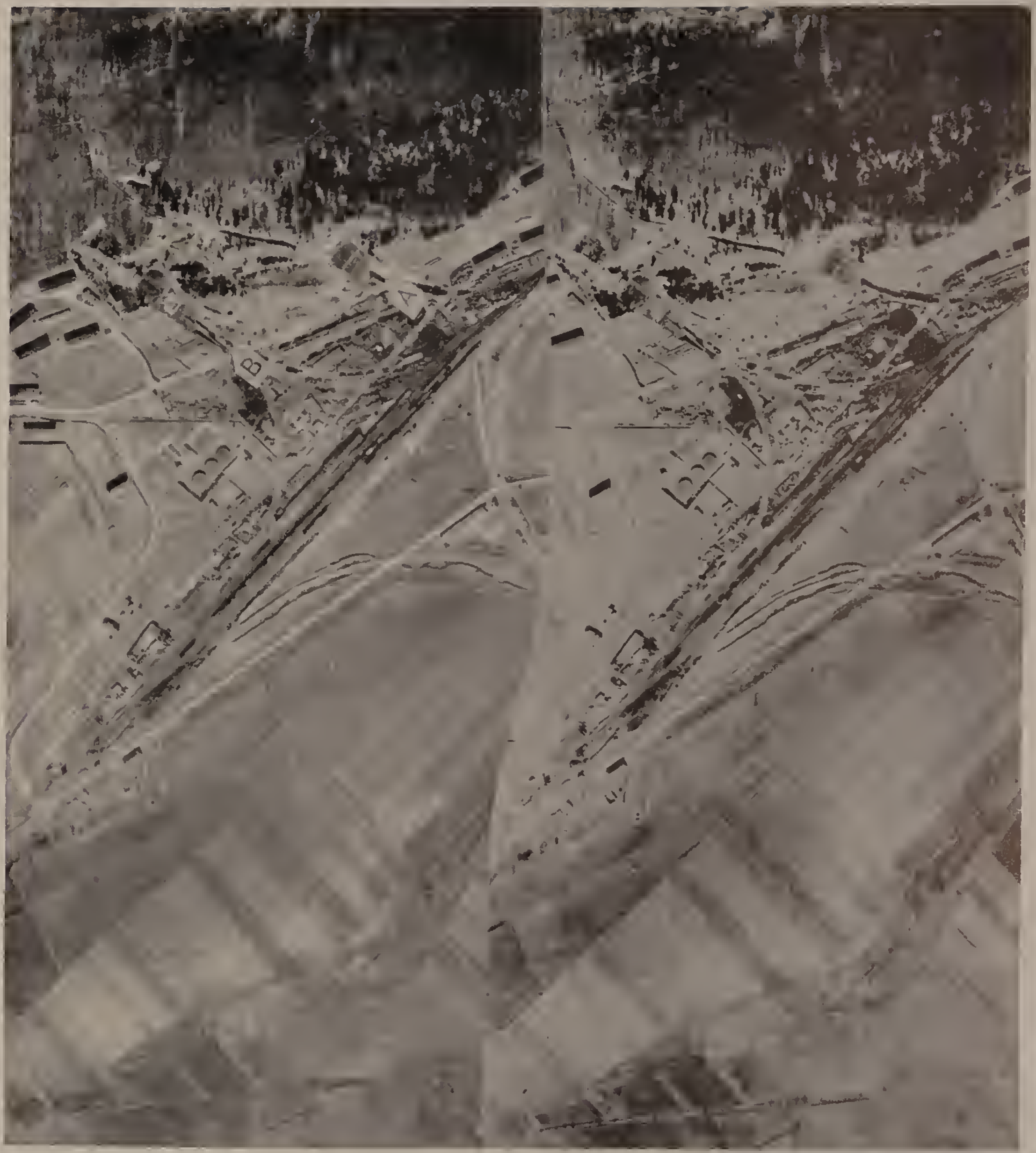


FIGURE 66. Stereogram of camouflaged entrance to V–1 and V–2 underground factory at Niedersachswerfen, Soviet Zone, Germany. A ground view of Entrance A is shown in Fig. 65. The camouflage here was ineffective because it was too angular in pattern, differed in tone and texture from the adjacent ground and thus did not blend in with its surroundings. The standard gauge railway track leading into the underground factory gave away the presence of the tunnels anyway so that any camouflage of this type, regardless of how good it was, would almost certainly have been a failure.

Cover: Prints 4205–4206 of Sortie 106G 4779, dated 14 March 1945.

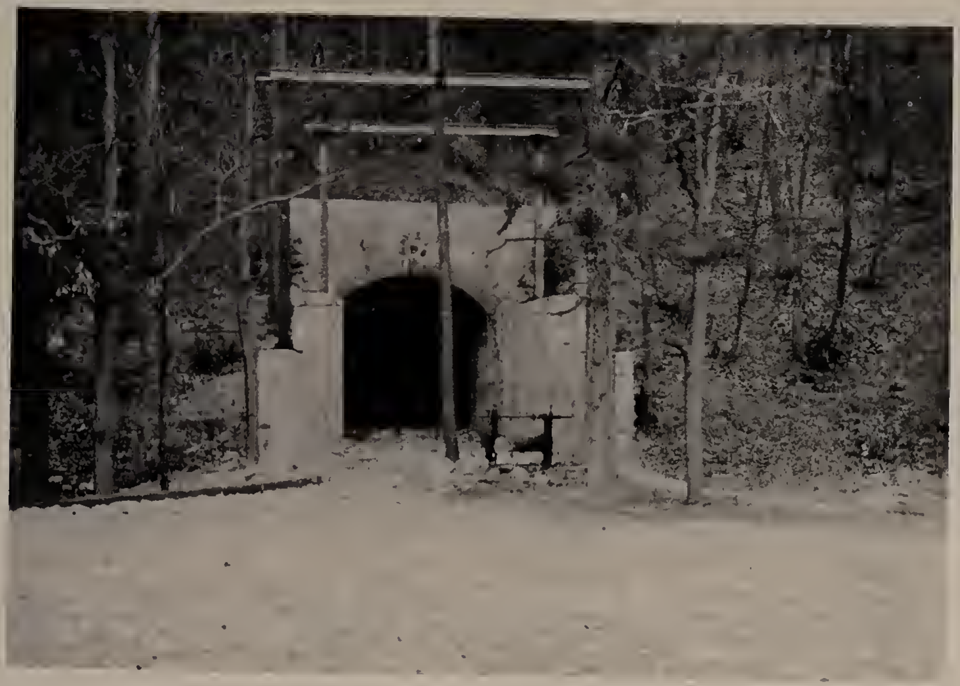


FIGURE 67. Natural growth of trees left standing as camouflage for tunnel entrance (No. 2) at the Henschel underground aircraft engine parts factory near Elberberg, U. S. Zone, Germany. All six entrances were camouflaged in this manner. This factory was scheduled to start limited production in May 1945. It was captured in April. Photo by A–2, USAFE field team, 15 Feb 1946.

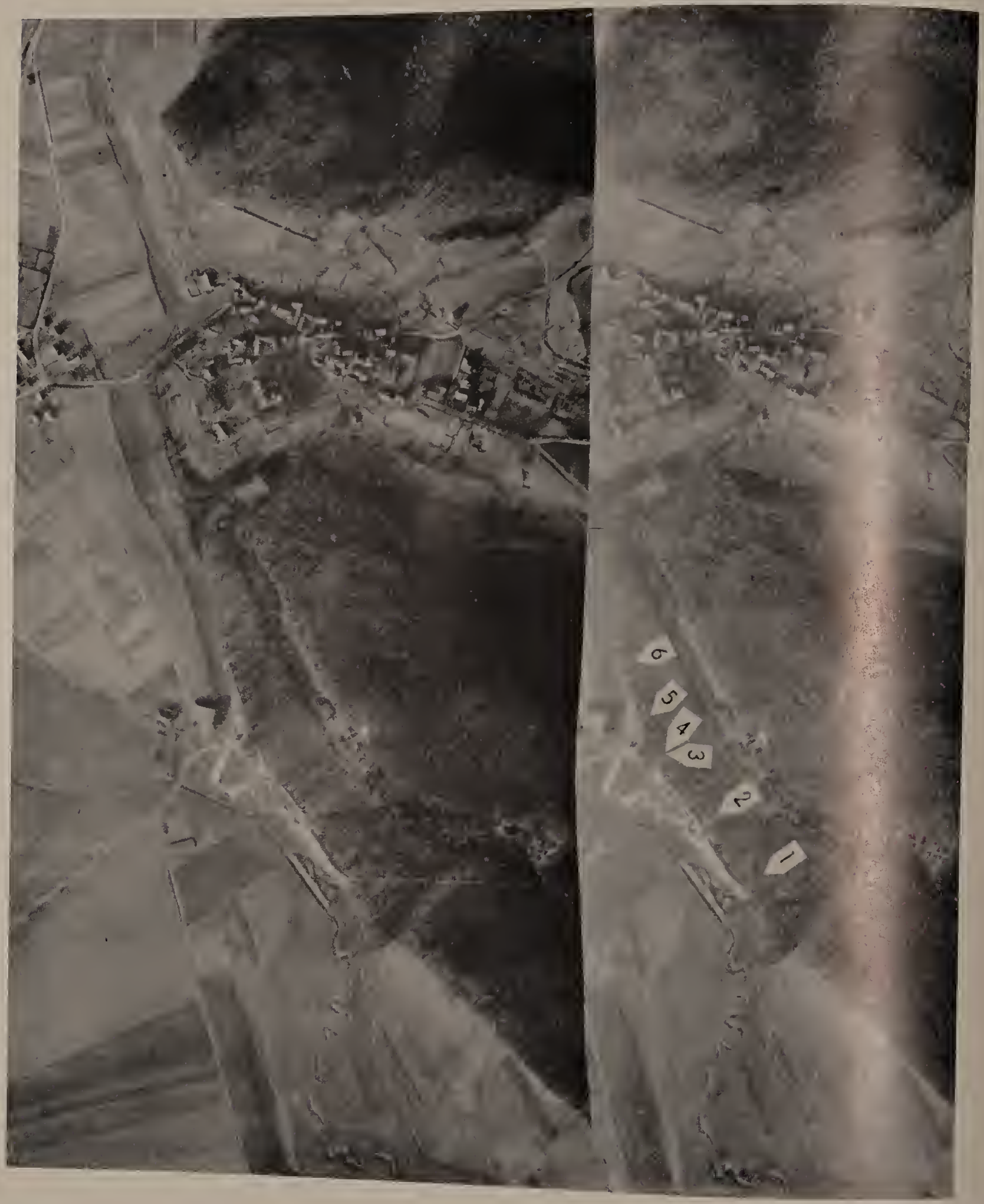


FIGURE 68. Stereogram of Henschel underground aircraft engine parts factory near Elberberg, U. S. Zone, Germany. The location of the six entrances is shown (right). Although the entrances are well concealed by trees their presence is indicated or suggested by the short roads leading from them to the waste dump. The waste dump was partially camouflaged by soil which was dug ahead of the advancing waste dump and transported on to it by a portable belt conveyor. An attempt was made to camouflage the inclined face of the waste dump by covering it with branches of trees obtained from the nearby forests but as can be seen this was not very successful.

Cover: Prints 4226–4227 of Sortie 106G/4838, dated 15 March 1945.

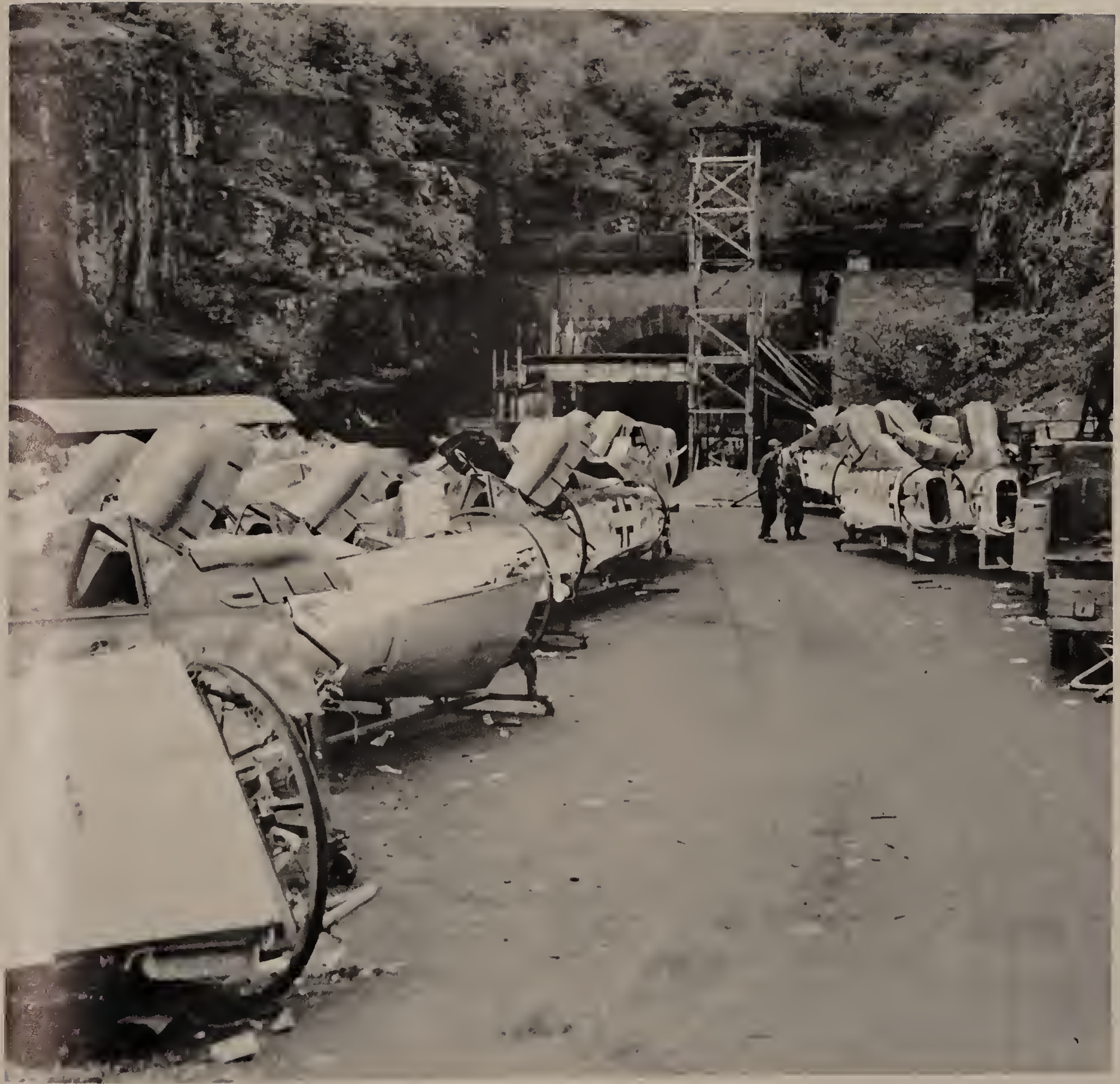


FIGURE 69. Open-air storage of damaged aircraft fuselages at an underground repair facility in a railway tunnel at Gevelsberg, British Zone, Germany. An aerial view of this underground site is shown in Fig. 70. AF Neg. No. 62315 A. C.

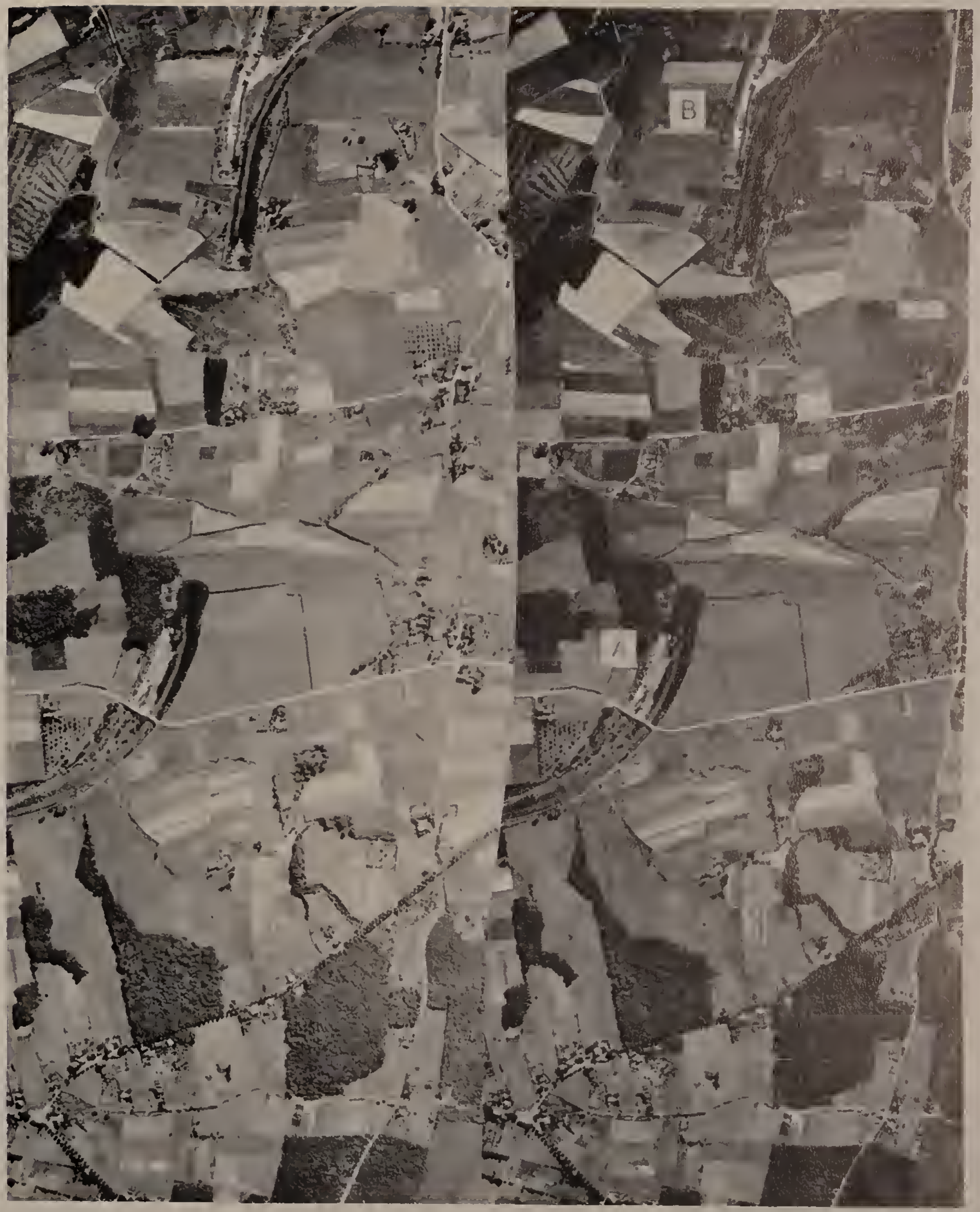


FIGURE 70. Stereogram of the Espenlaub Fleugzengbau repair facility in a railway tunnel at Gevelsberg, British Zone, Germany. The ground photograph shown in Fig. 69 was taken at entrance A. Note the damaged aircraft fuselages stored outside the tunnel entrance. Note also that the track was blocked at both ends of the tunnel by new buildings.

Cover: Prints 3242–3243 of Sortie 106G/LIB 303, dated 3 Sept. 1945.

Cranes and hoists were fairly common features at many German underground factories and were one of the more reliable photo interpretation keys to the identification of such installations. These cranes and hoists were of different sizes and designs. Some were made of steel and some of wood. Some were erected in a fixed position while others could be moved back and forth on little wheels (traveling cranes). They were almost always located at or near tunnel entrances. They indicate trans-shipment points where bulky and heavy loads were loaded onto, or unloaded from, trucks and standard gauge railway cars which served the factories. Narrow gauge railway cars commonly were used for moving the loads into and out of the factory.

Cranes and hoists may or may not be present outside of those underground factories that have tunnels large enough to do the loading and unloading underground. Several German underground factories had transportation tunnels of sufficient size to permit trucks and standard gauge railway cars to be moved directly inside the underground factories.

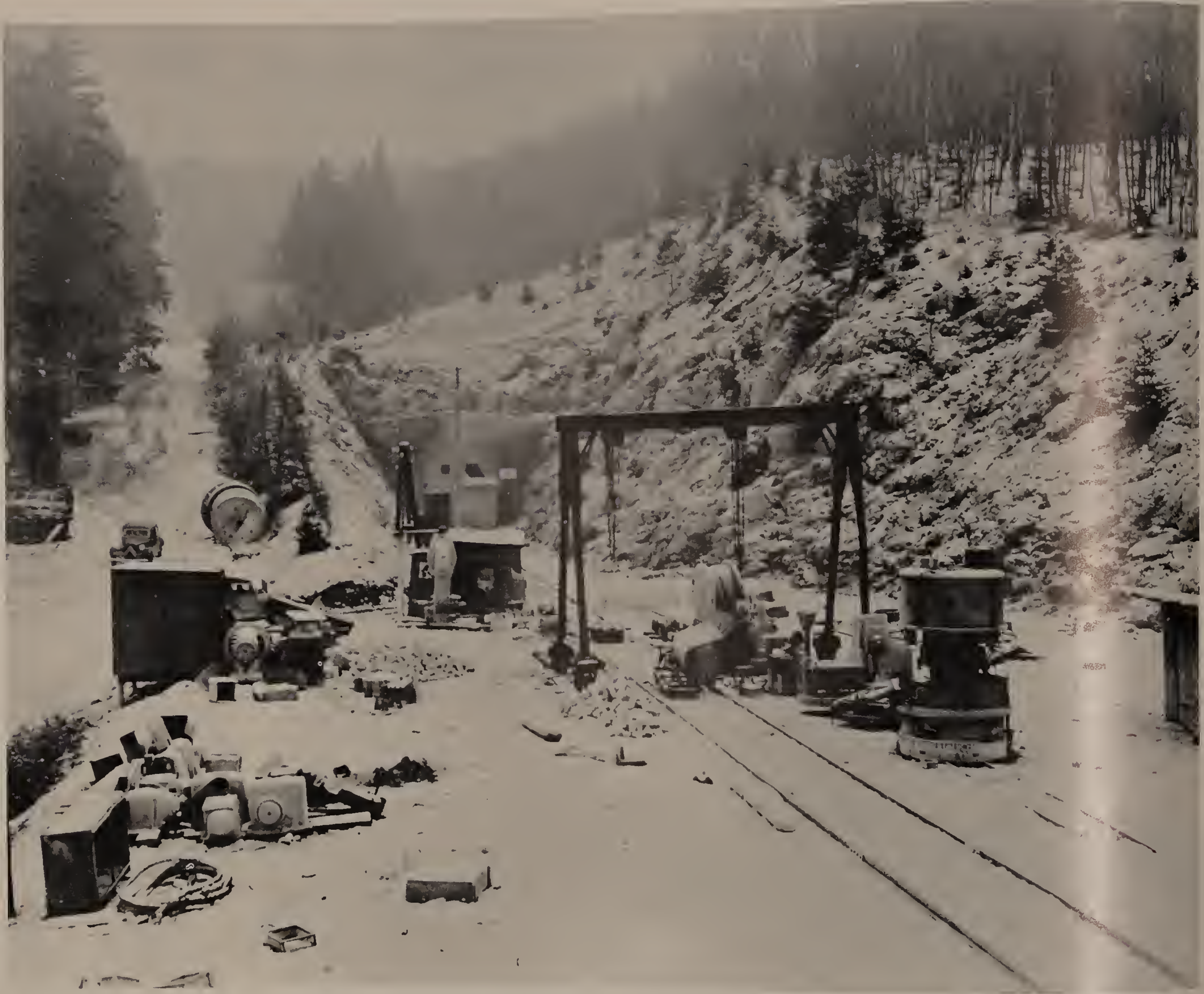


FIGURE 71. Monorail hoist at entrance to the Continental Metal Werk underground factory in a railway tunnel at Langenaubach, U. S. Zone, Germany. Production of 300 propeller hubs a month for FW 190 and Me 109 aircraft was planned. The factory was nearly ready to start production when captured. The machine tools were being removed from the factory when the photograph shown above was taken. The hoist was being used for unloading the machinery from narrow gauge railway cars and then for reloading it onto standard gauge cars. Photo by A–2, USAFE, Feb 1946.

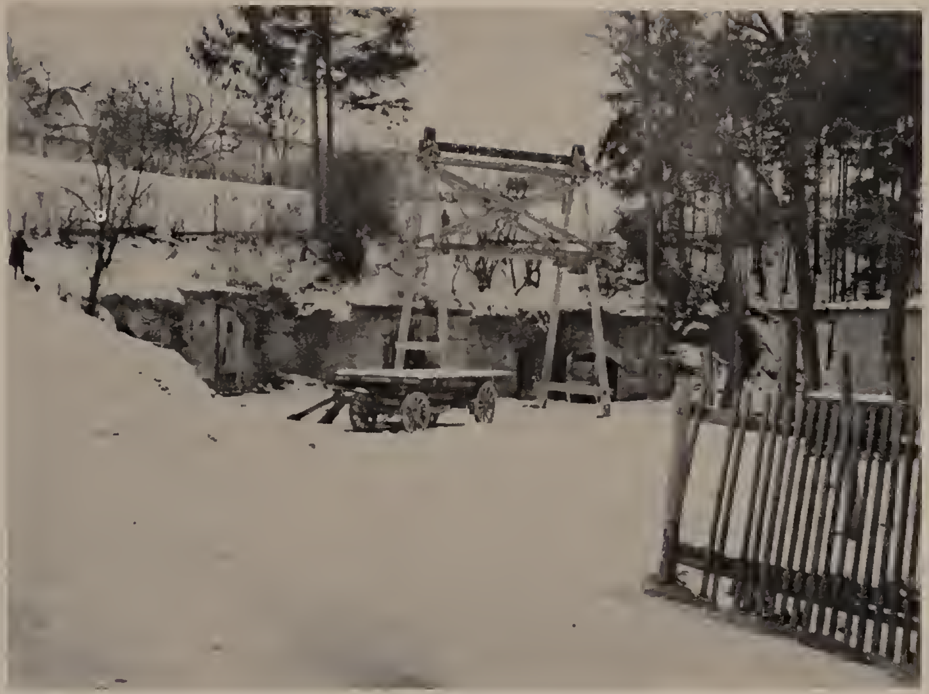


FIGURE 72. Wooden frame for a hoist at the entrance to the K. G. Mueller A. G. Kugellagerfabrik in an extended natural cave at Ansbach, U. S. Zone, Germany. The hoisting gear had been removed when the photograph shown above was taken. This underground factory was built for production of ball bearing rings and gauges. The cave was formerly used for the storage of beer. Photo by A–2, USAFE, Feb 1946.

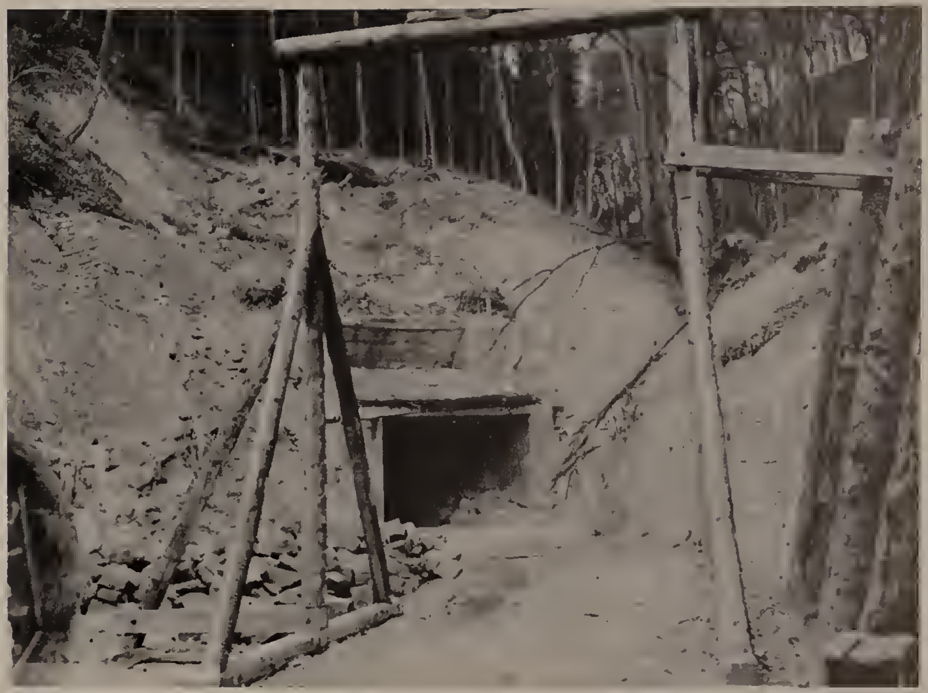


FIGURE 73. Wooden frame for a hoist at the Daimler Benz underground factory in an old gypsum mine at Neckarelz, U. S. Zone, Germany, code name Brasse. The hoisting gear had been removed when the above photograph was taken. This factory was being built for the production of cowlings for D. B. 605 aircraft engines but was not completed when World War II ended. Photo by A–2, USAFE. 1946.

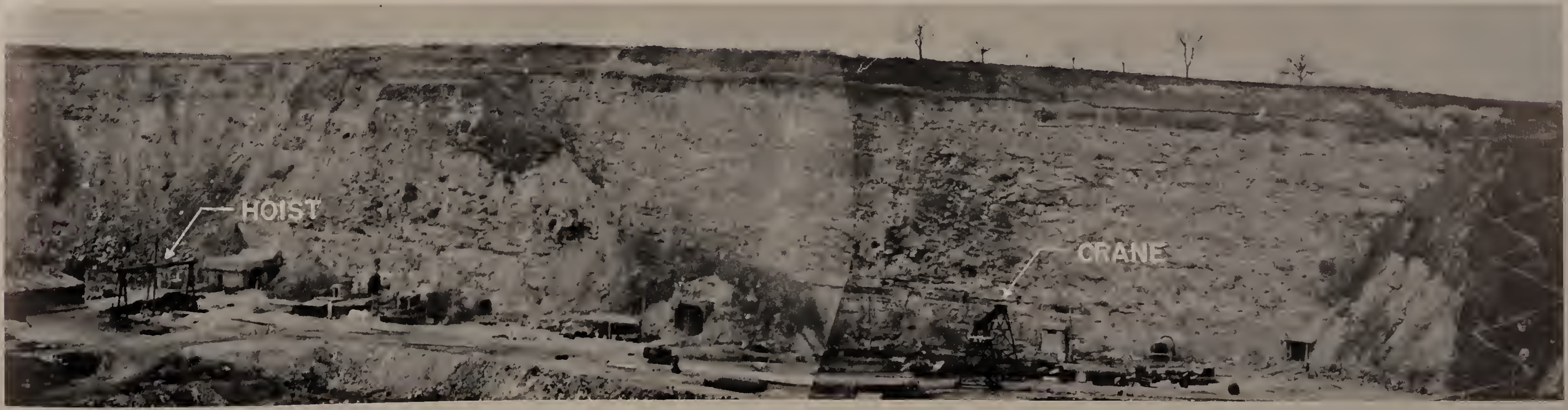


FIGURE 74. A traveling crane and a hoist at the M. A. N. underground factory at Weisnau, French Zone, Germany. An aerial view of this site is shown in Fig. 39. Photo by A–2, USAFE, 1946.

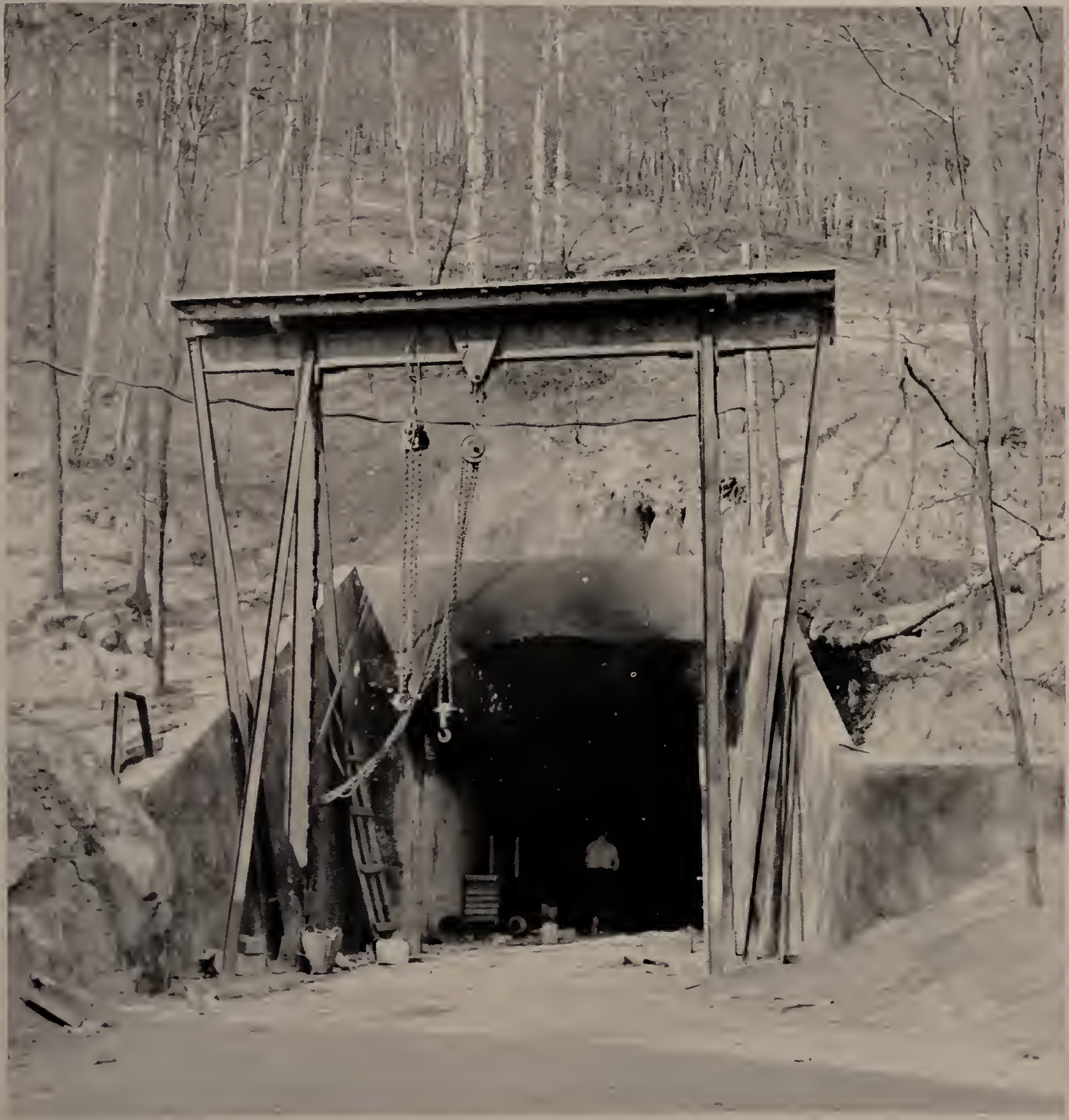


FIGURE 75. Chain hoist supported by a steel frame at Entrance No. 1 to the Reimahgbau GmbH underground aircraft factory at Kahla, Soviet Zone, Germany. An aerial view of this hoist is shown in Fig. 76. Air Force Photo Neg. No. 57264 A. C.

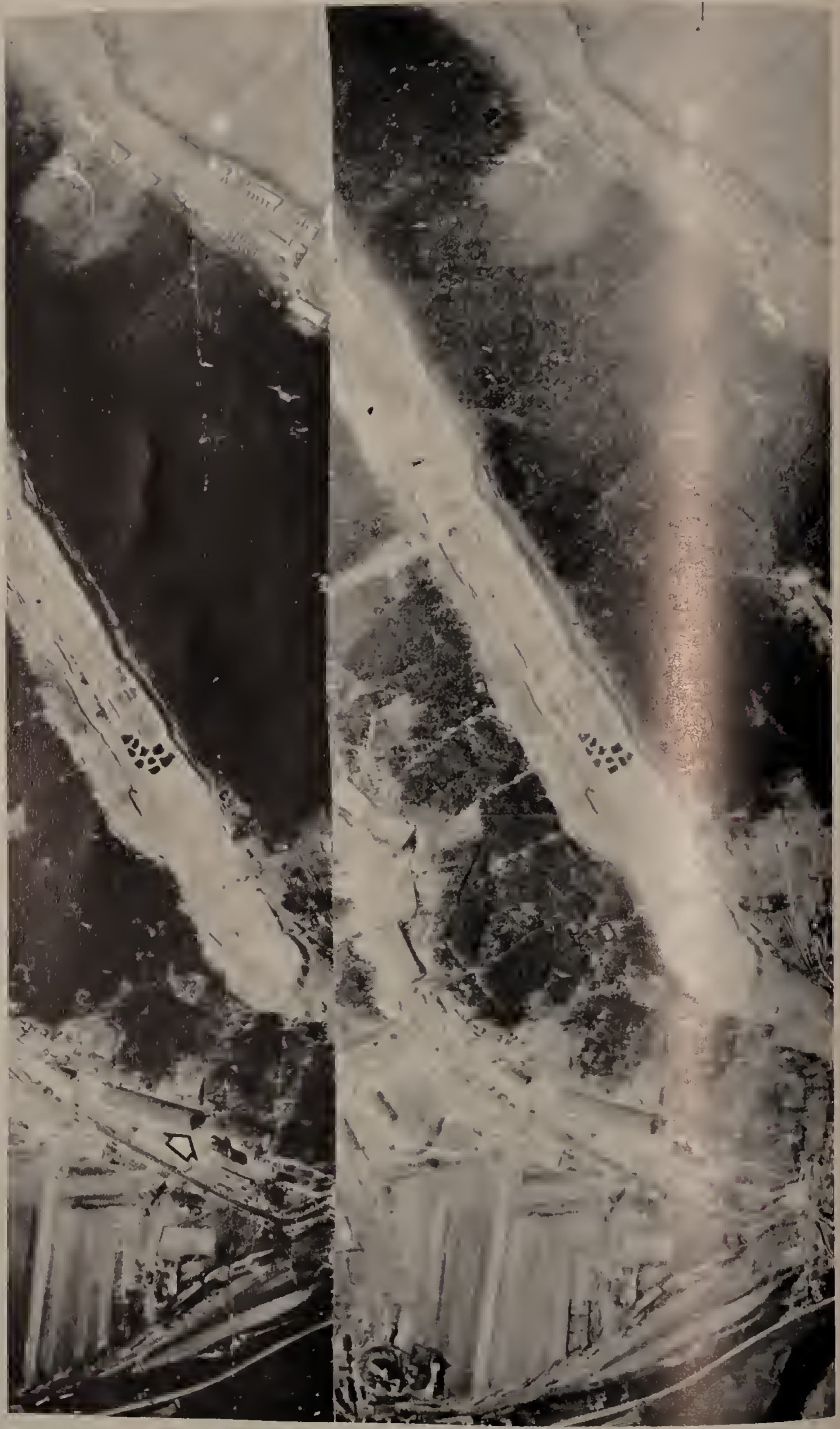


FIGURE 76. Stereogram of the steel frame supporting a chain hoist shown in Fig. 75.

Cover: Prints 3039–3040 of Sortie 106G/4918, dated 19 March 1945.

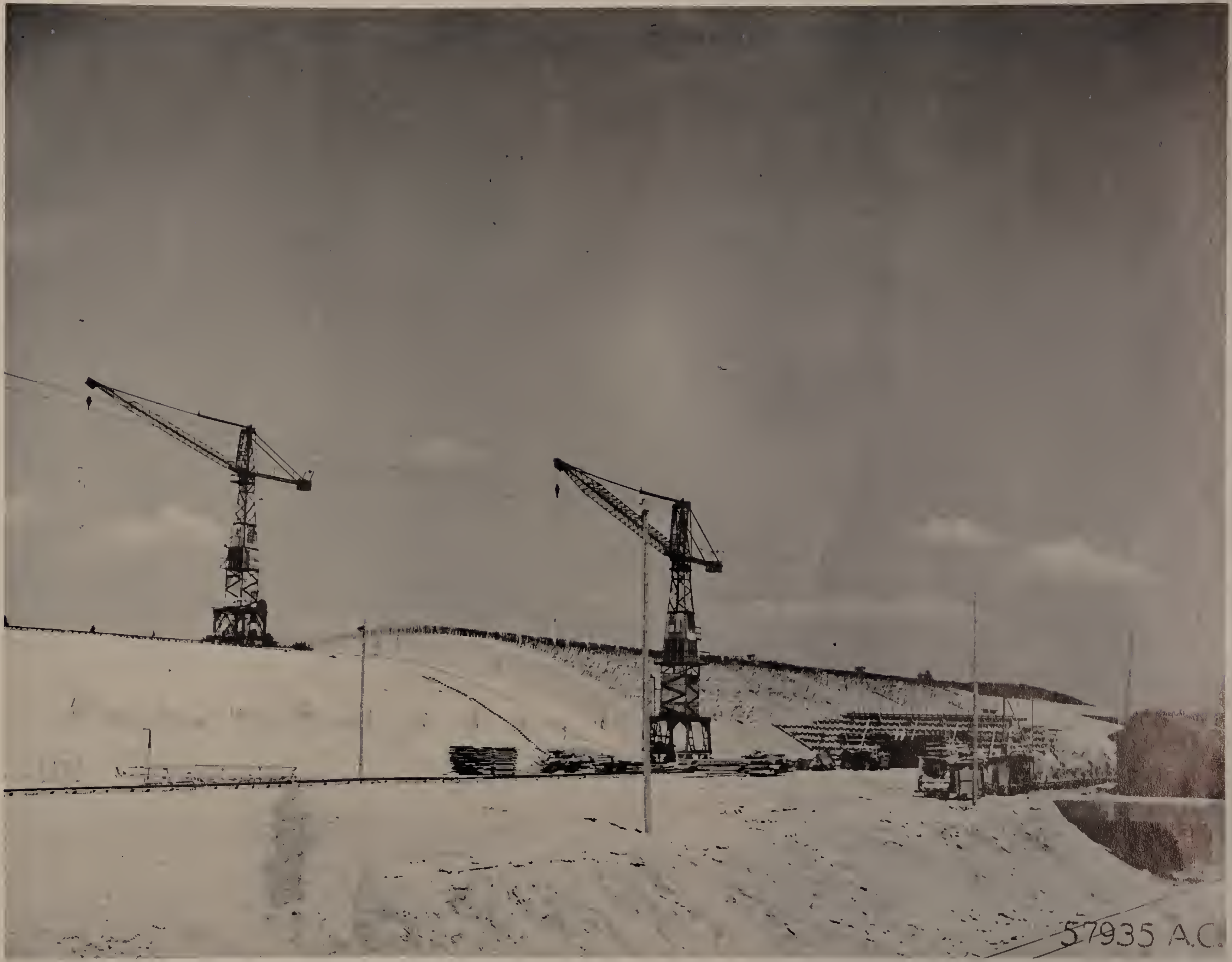


FIGURE 77. Revolving elevated cranes at the semi-underground factory building under construction at Muhldorf, U. S. Zone, Germany. These cranes were used only for construction purposes. Air Force Photo, Neg. No. 57935 A. C.

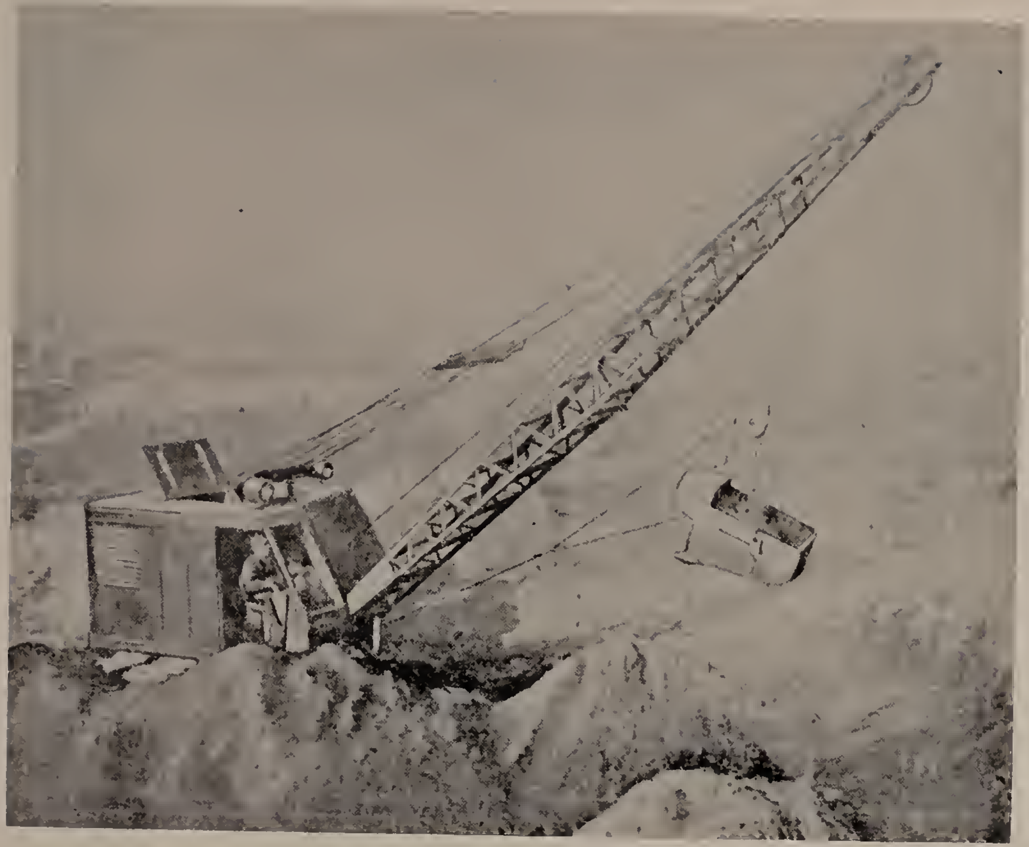


FIGURE 78. Soviet dragline crawler-type crane.

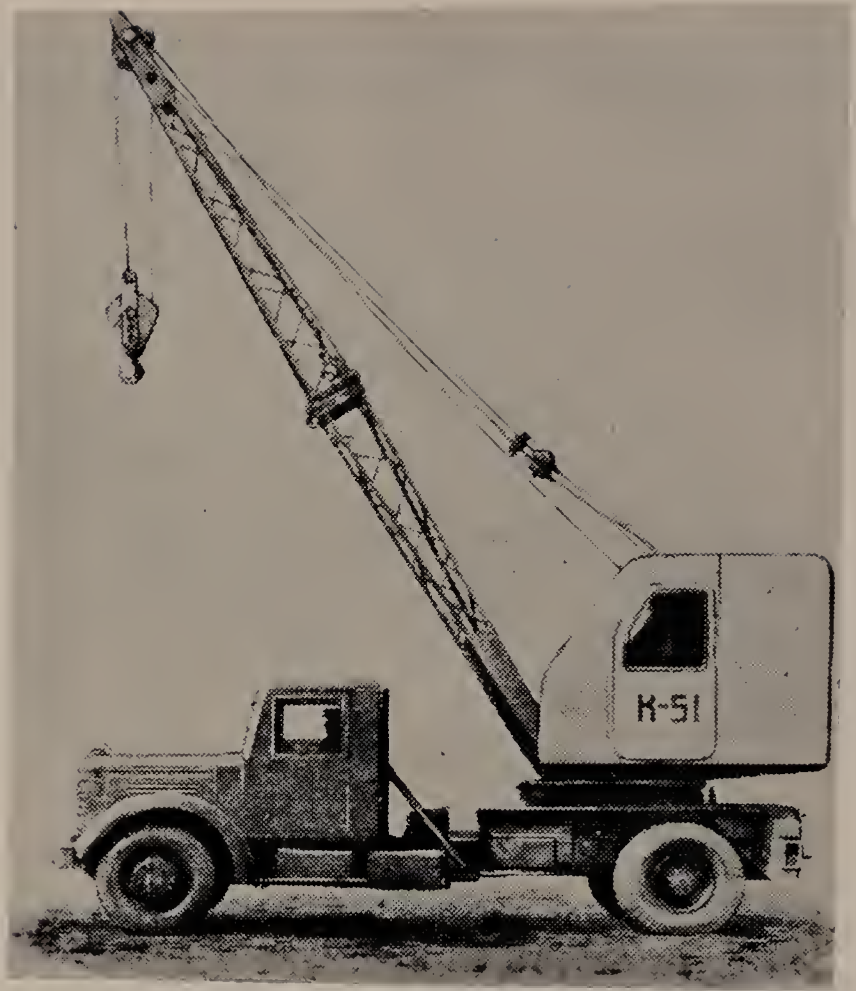


FIGURE 79. Soviet motorized crane.

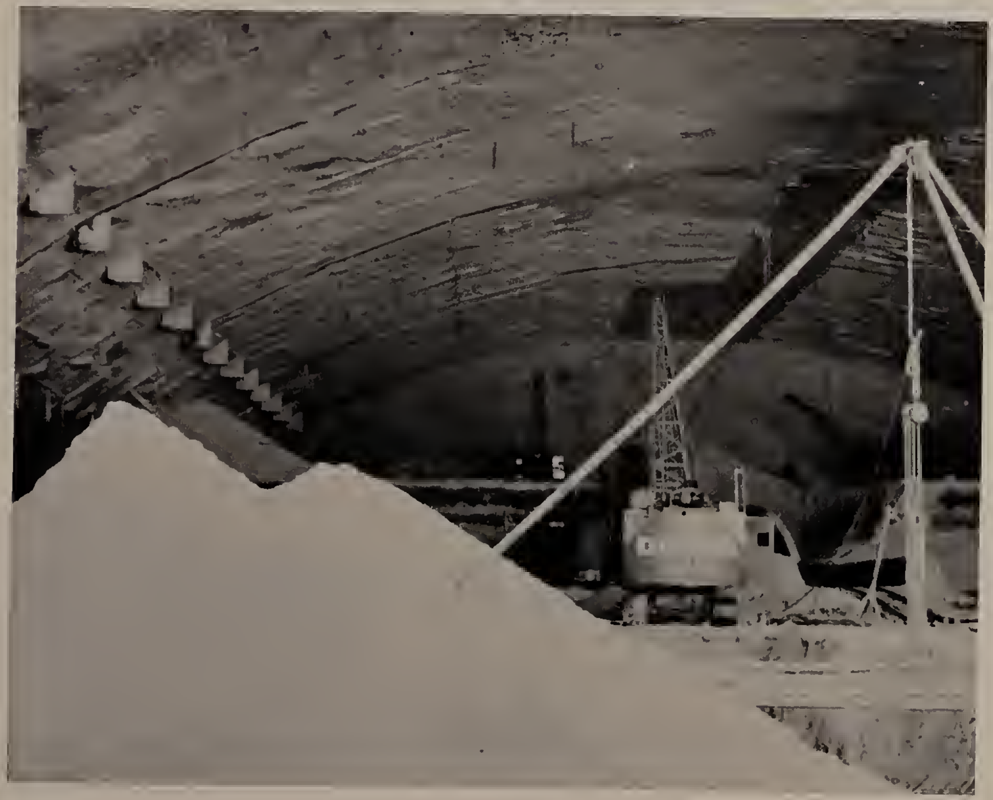


FIGURE 80. German dragline crawler-type cranes. Tripod hoist in foreground. View shows interior of the semi-underground factory building (Bunkerwerke) while under construction at Muhldorf, U. S. Zone, Germany. Air Force Photo No. C–57936–AC.

A considerable variety of construction and excavating equipment was utilized by the Germans in the excavation and construction of underground factories during World War II. Nearly all of this equipment was drawn from the mining and construction industries and state agencies. Narrow gauge railway dump cars and the various types of engines which pulled them were present in large numbers. Associated with them were steam shovels, dragline crawler-type cranes and various types of mechanical loaders. Some loaders utilized a conveyor belt while others employed a dragline; some were built of wood and were in a fixed position while others were made of steel and could be moved about on wheels. The Saltzgitter loader was mounted on narrow gauge track, was operated by compressed air and simply scooped up a load of rock and tossed it over itself into a dump car behind. Various types of compressed air hand held drills and hammers were used for drilling holes for blasting operations. The compressors for supplying the compressed air were frequently located outside in buildings near the tunnel entrances. Core drilling rigs were used for obtaining samples of rock. Other types of drilling rigs were used for drilling water wells and digging post holes. Mechanical ditch diggers also were used. Concrete mixers of various types and sizes were common and two tunnel boring machines are known to have been utilized. Much of this equipment is large enough to be identified on aerial photographs and is quite useful in the photo interpretation of underground installations while they are under construction. An aerial view of a steam shovel is shown in Figs. 1 and 2.

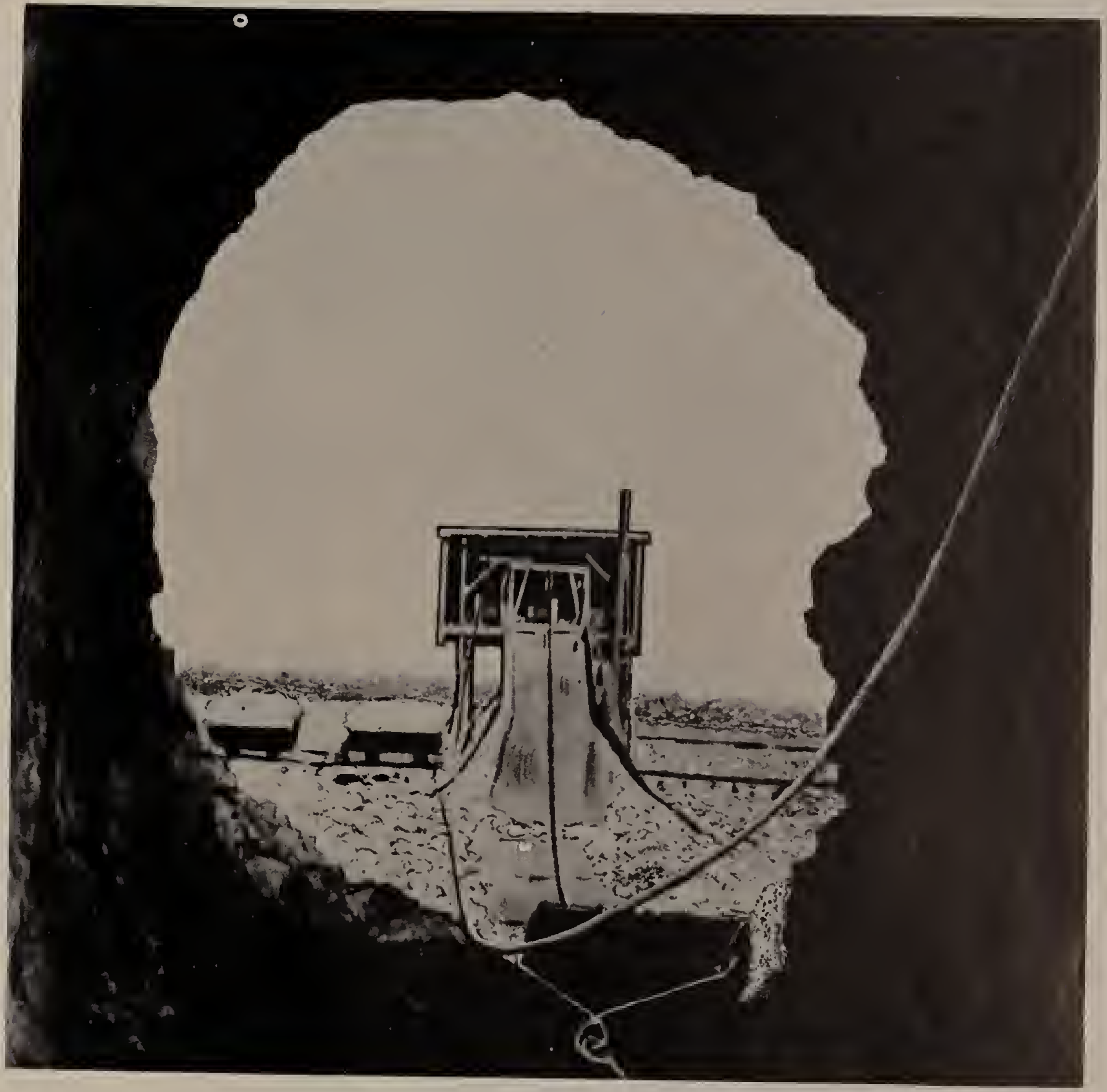


FIGURE 81. Loading tower employing a drag line at entrance to an underground synthetic aviation gasoline plant under construction in 1945 at Niedersachswerfen, Soviet Zone, Germany. The scoop was pulled by a steel cable out of the tunnel and up the steel ramp where the rock was tipped into a dump car beneath. The return cable was run over a pulley which was anchored high on the far wall of the tunnel. The drag line was operated by an electric motor. Photo by CIOS Team 163. Air Force Neg. No. 276580.

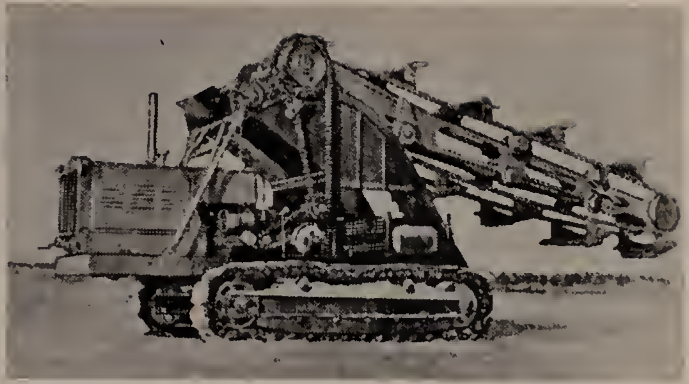


FIGURE 82. Soviet trench digger. Excavates trench 0.8 to 1.2 meters wide and 1.5 to 2.5 meters deep.

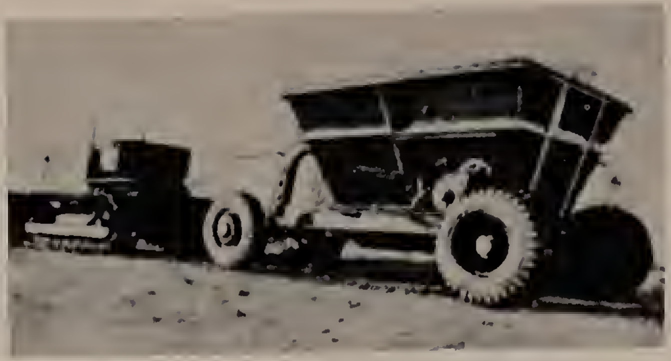


FIGURE 83. Soviet earth moving trailer.

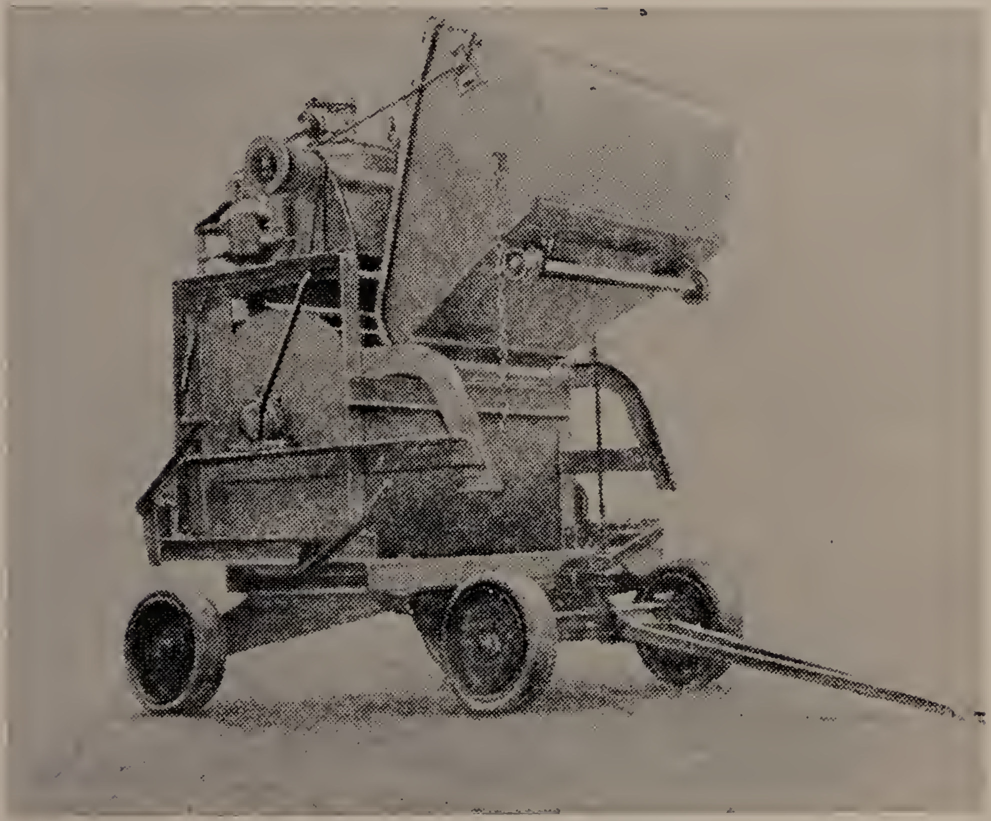


FIGURE 84. Soviet concrete mixer.

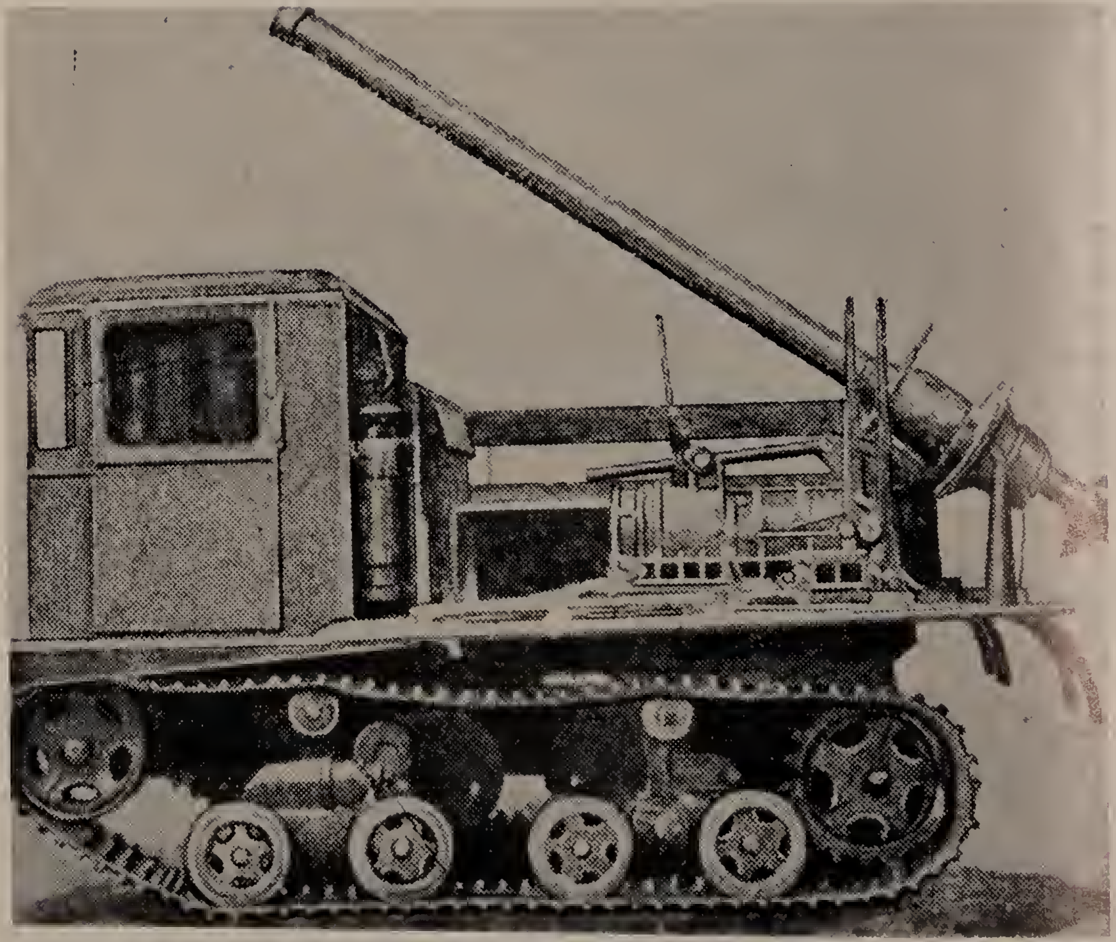


FIGURE 85. Soviet auger-type drill. Used for digging holes for telegraph and telephone poles.

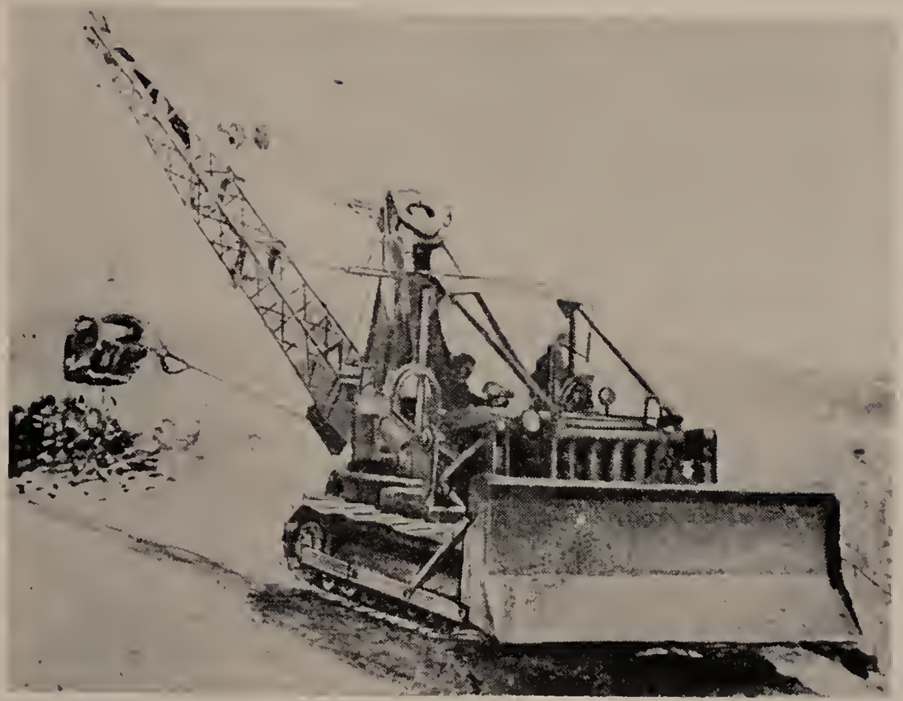


FIGURE 86. Soviet multipurpose tractor.

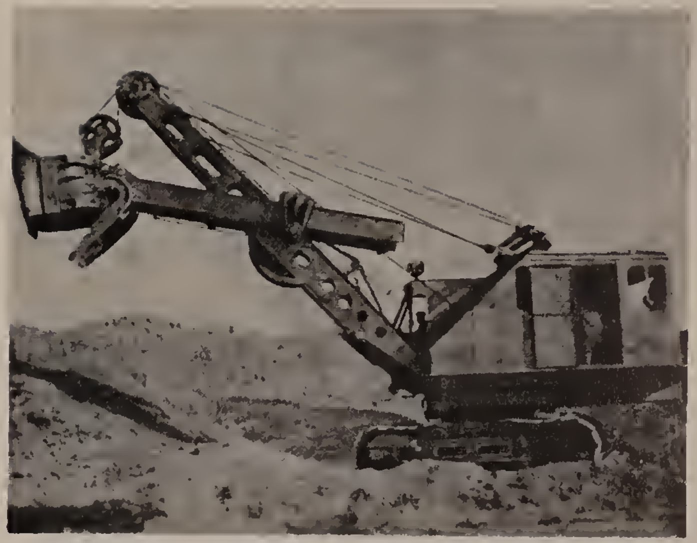


FIGURE 87. Soviet electric shovel.

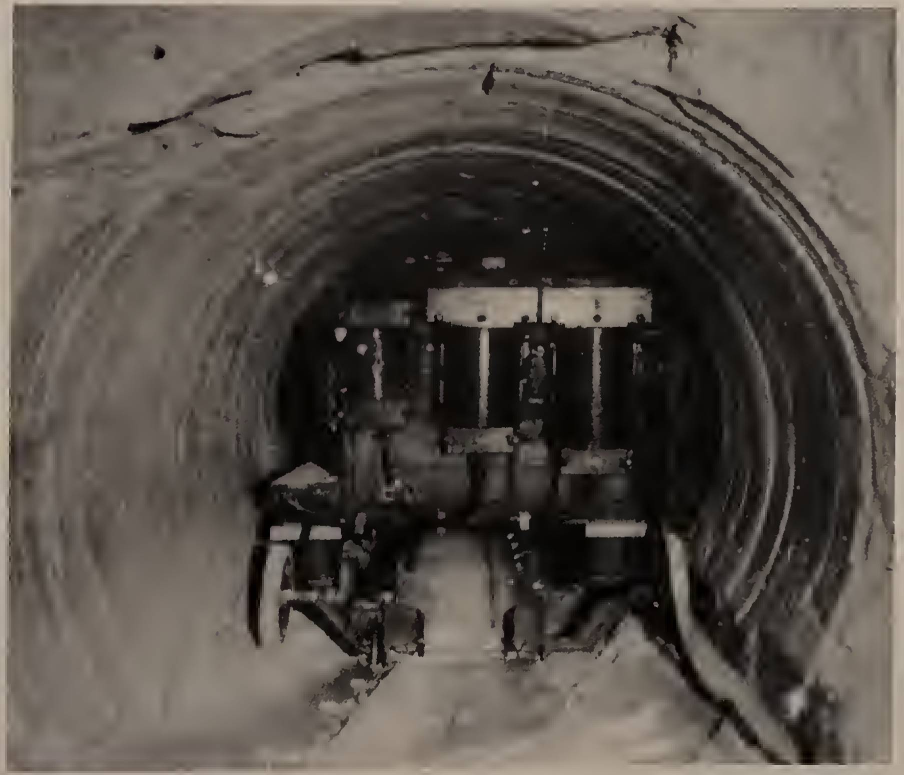


FIGURE 88. German tunnel-boring machine in the Schaffer and Bodenberg underground factory at Blankenburg, Soviet Zone, Germany. This machine could bore a tunnel ten feet in diameter. Photo by Capt. G. E. D. McBride, CIOS Team 163, May 1945. AF Neg. No. 276568.

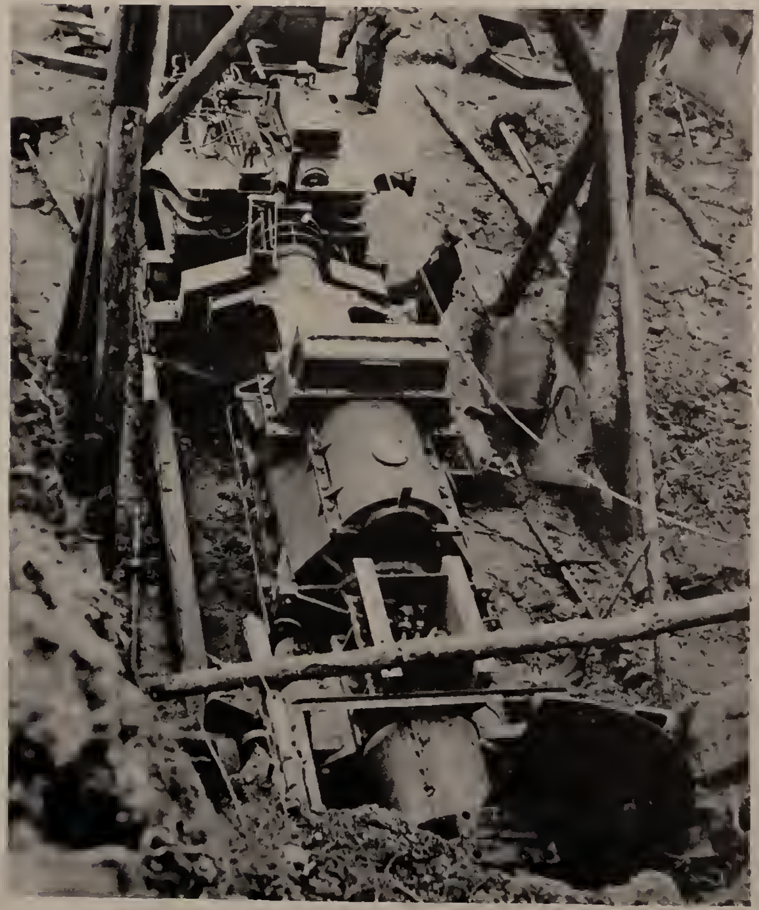


FIGURE 89. German tunnel-boring machine at the large underground factory under construction in 1945 near Happurg, U. S. Zone, Germany. Photo by A–2, USAFE, 1946. AF Neg. No. 276575.

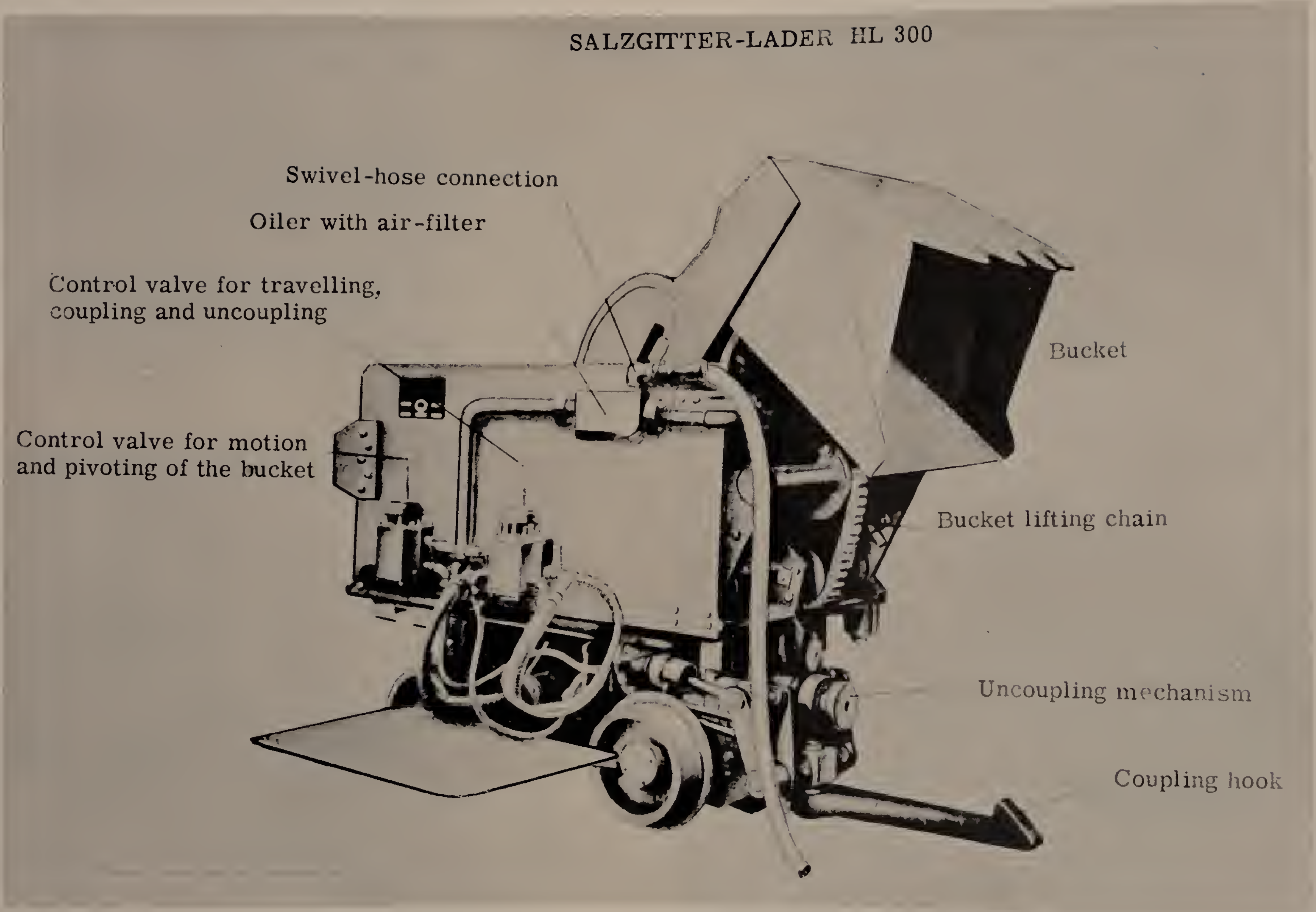


FIGURE 90. A German mucking machine, the Salzgitter Lader, manufactured by the Herman Goring Werke fur Bergbau und Huttenbedarf A. G., Salzgitter. This macine is used for loading material into narrow gauge railway cars or onto belt conveyors. It is similar in design to several American machines and uses the "over the shoulder principle." It is used for ore, coal, potash—above and below ground—on sand, gravel, lime or slate; on deep excavations, railway work and tunnels. The Salzgitter-Lader can be used in a tunnel as small as 5 ft. 10 in. wide and 7 ft. 6 in. high. It operates on a track 484 mm or 1 ft. 7 in. wide. Operation is by compressed air. When the bucket is in the lowered position for loading it can be swung from side to side through a 60 degree arc (30 degrees each side). The filled bucket is guided during the raising motion and in its passage to the emptying position in such a manner that lateral motion is prevented. In the view shown above the bucket is in the dump or emptying position. The over-all length of the machine with the bucket lowered is eight feet, eight inches, and with the bucket raised five feet, nine inches. A smaller but similar machine, the Scrapper Lader, also was used.

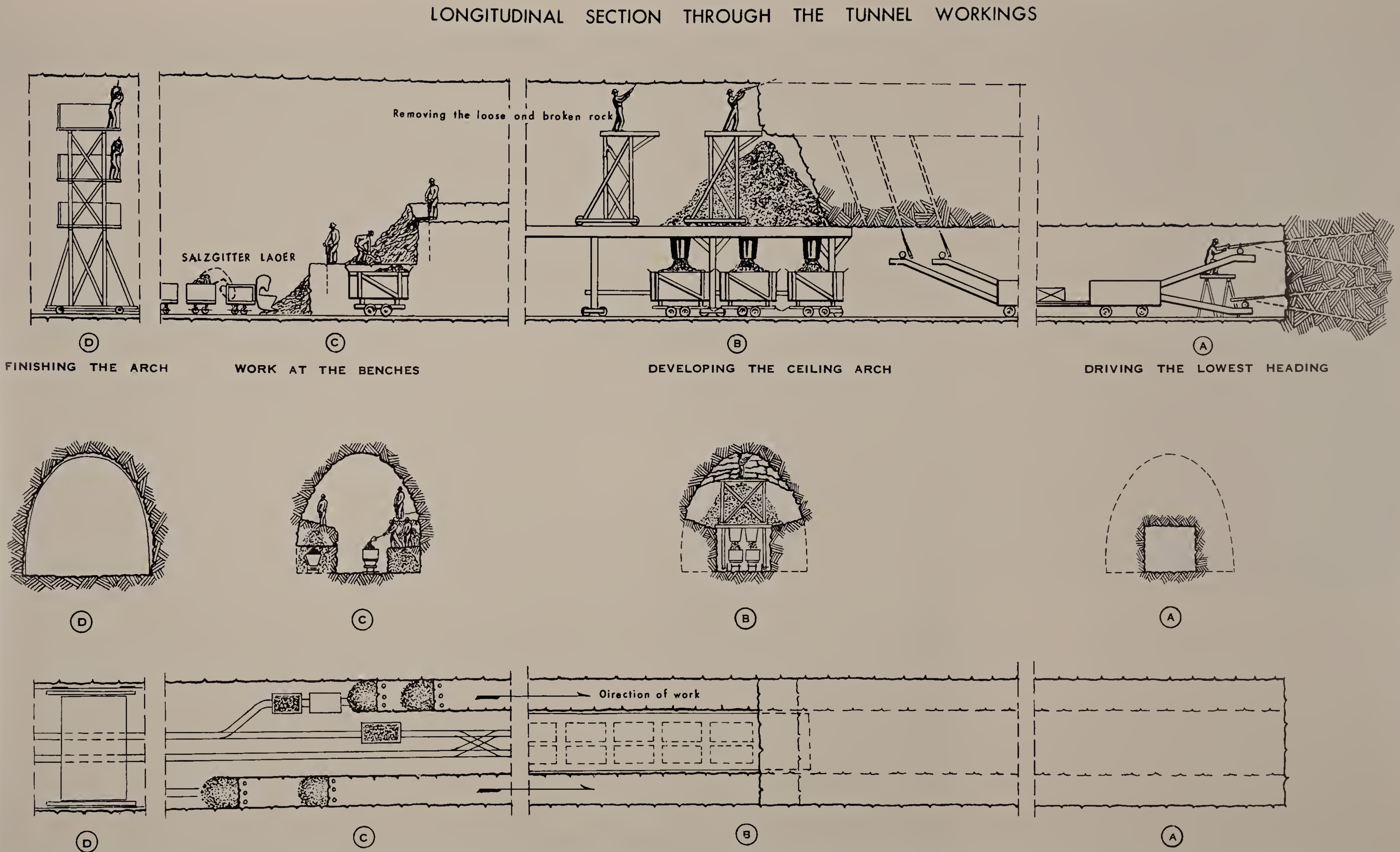
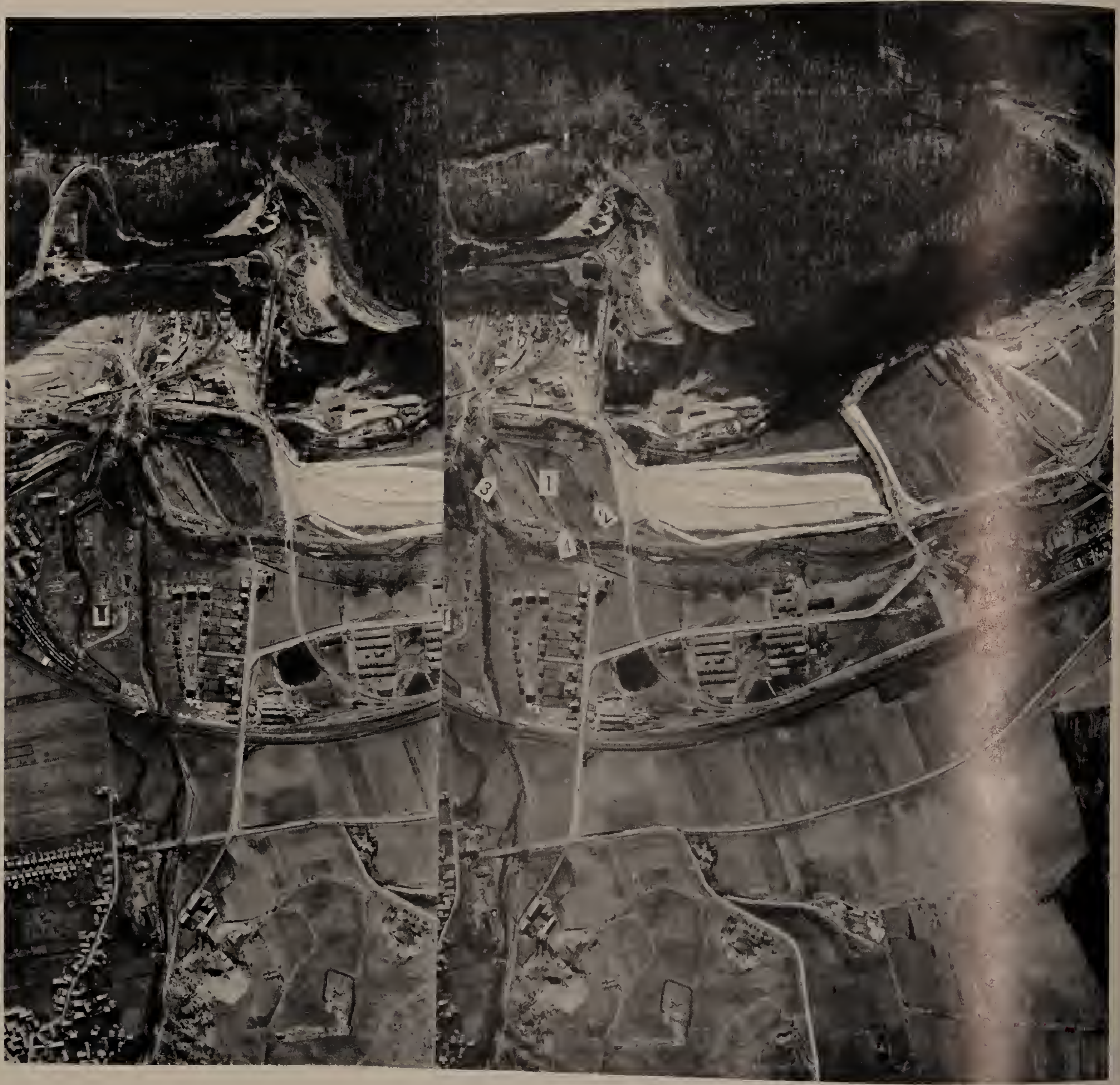

LONGITUDINAL SECTION THROUGH THE TUNNEL WORKINGS
Removing the loose and broken rock
SALZGITTER LADER
D
FINISHING THE ARCH
C
WORK AT THE BENCHES
B
DEVELOPING THE CEILING ARCH
A
DRIVING THE LOWEST HEADING
D
C
B
A
Direction of work
D
C
B
A

FIGURE 91. Diagrammatic drawing of a common construction technique utilied in Germany for the excavation of tunnels for underground factories in World War II. Different techniques were used depending upon the size of the tunnels and the character of the rock. At some sites the pilot tunnel was driven at roof level instead of floor level. For wide tunnels (approx. 50 feet) in weak rock three or four pilot tunnels were driven simultaneously and a masonry, brick or concrete lining put in piecemeal. Tunnels in self-supporting rock were rarely lined. The arch roof was common in new tunnels. The construction equipment, dump cars, the Saltzgitter loader and the scaffolding can be seen on aerial photographs. This drawing is based on a German drawing by Dr. Eng. H. H. Kress.

FIGURE 92. Sand and gravel pit (1) opposite four underground installations (three under construction) in the East end of the Kohnstein at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. Note the steam shovel (2), dragline crane (3), and narrow gauge railway cars (4), in the pit. During the construction of many underground installations, sand and gravel are required to make concrete. For economical reasons it is obtained from sources as near the installation as possible.

Cover: Prints 3204–3205 of Sortie 106G/4779, dated 14 March 1945.



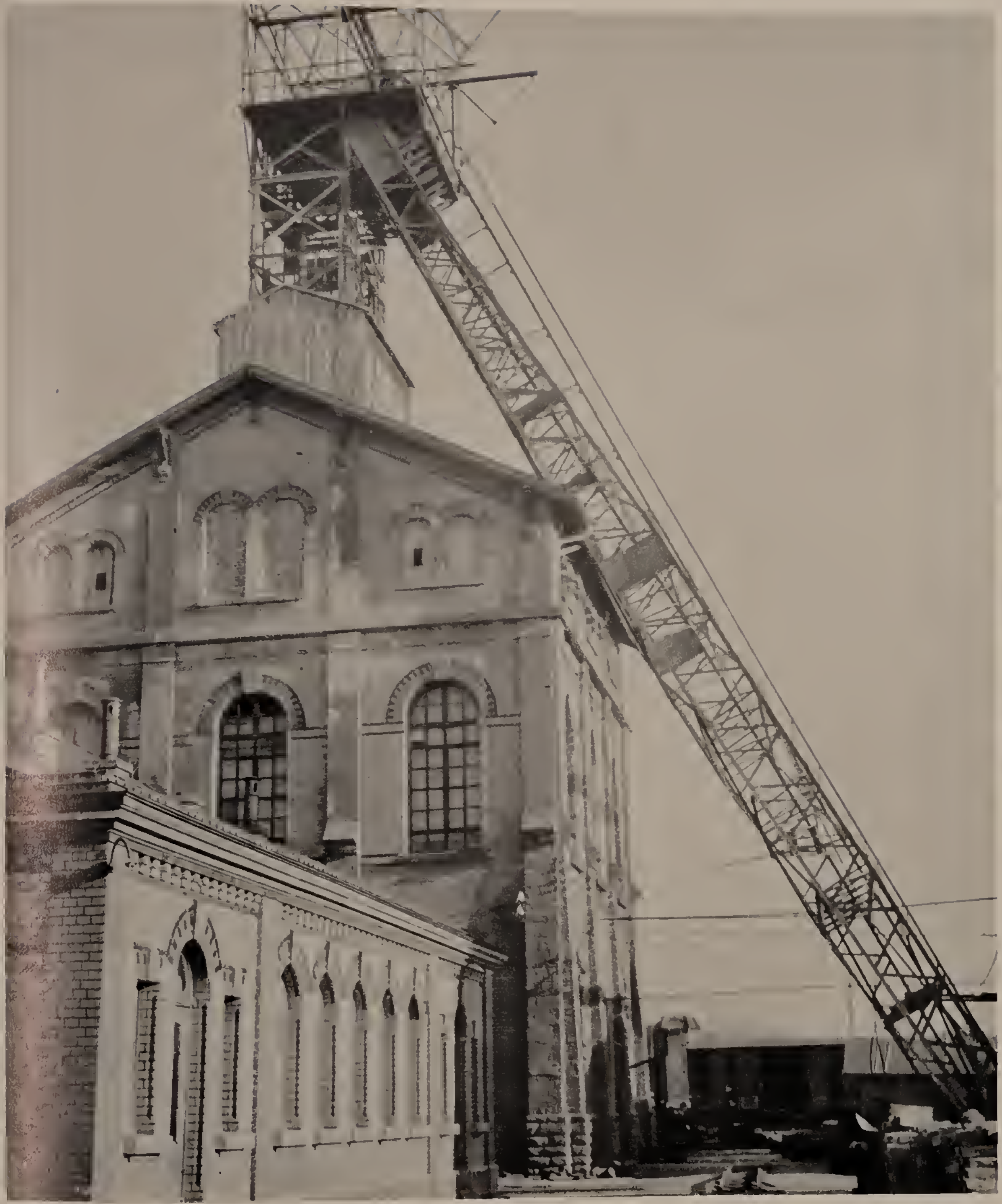


FIGURE 93. Old shaft house at the Koenig Wilhelm II salt mine at Kochendorf, U. S. Zone, Germany. This mine is entered by a single vertical shaft 590 feet deep. This view shows the shaft house which is over the entrance to the shaft, the steel headframe which supports the cage, two steel legs or braces of the headframe, the large wheel or sheave at the top of the headframe, and the cables extending from the sheave to the hoist house to the right. The hoist house is not shown. An aerial view of this mine is shown in Fig. 94. Photo by A–2, USAFE, 1946.

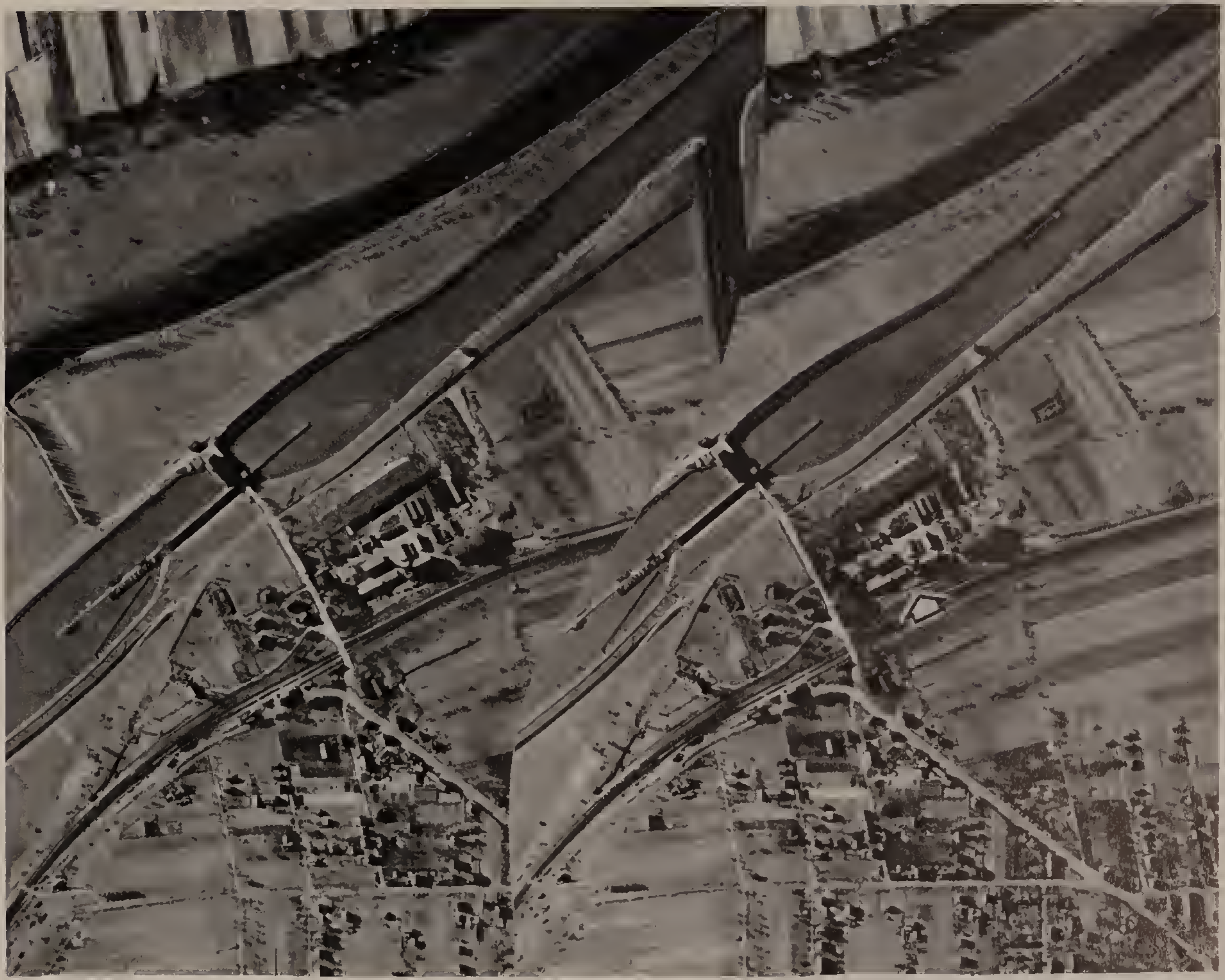


FIGURE 94. Stereogram of salt mine at Kochendorf, U. S. Zone, Germany. Note the appearance of the shaft house, the headframe, and that the hoist house is in direct line with the headframe and opposite the two inclined legs or braces of the headframe. These braces are characteristic features of headframes, are often times easy to identify on aerial photographs, and thus are an important and useful key to the confirmation of the presence of a vertical shaft mine. Some headframes are either partially or entirely enclosed. However, the side containing the braces is likely to be sloping and directly opposite and in line with a small building—the hoist house. On some photographs of large scale the cables can be seen. The above photographs were taken before work was begun on the installation of an underground factory in this mine. Seven firms were to share this mine but only one, Heinkel and Co., actually set up a factory here. A few jet aircraft engines were produced in this underground factory before the mine was captured. Additional shafts were being excavated at this site.

Cover: Prints 4035–4036 of Sortie J/423, dated 24 Feb 1944. Scale 1/10,000.

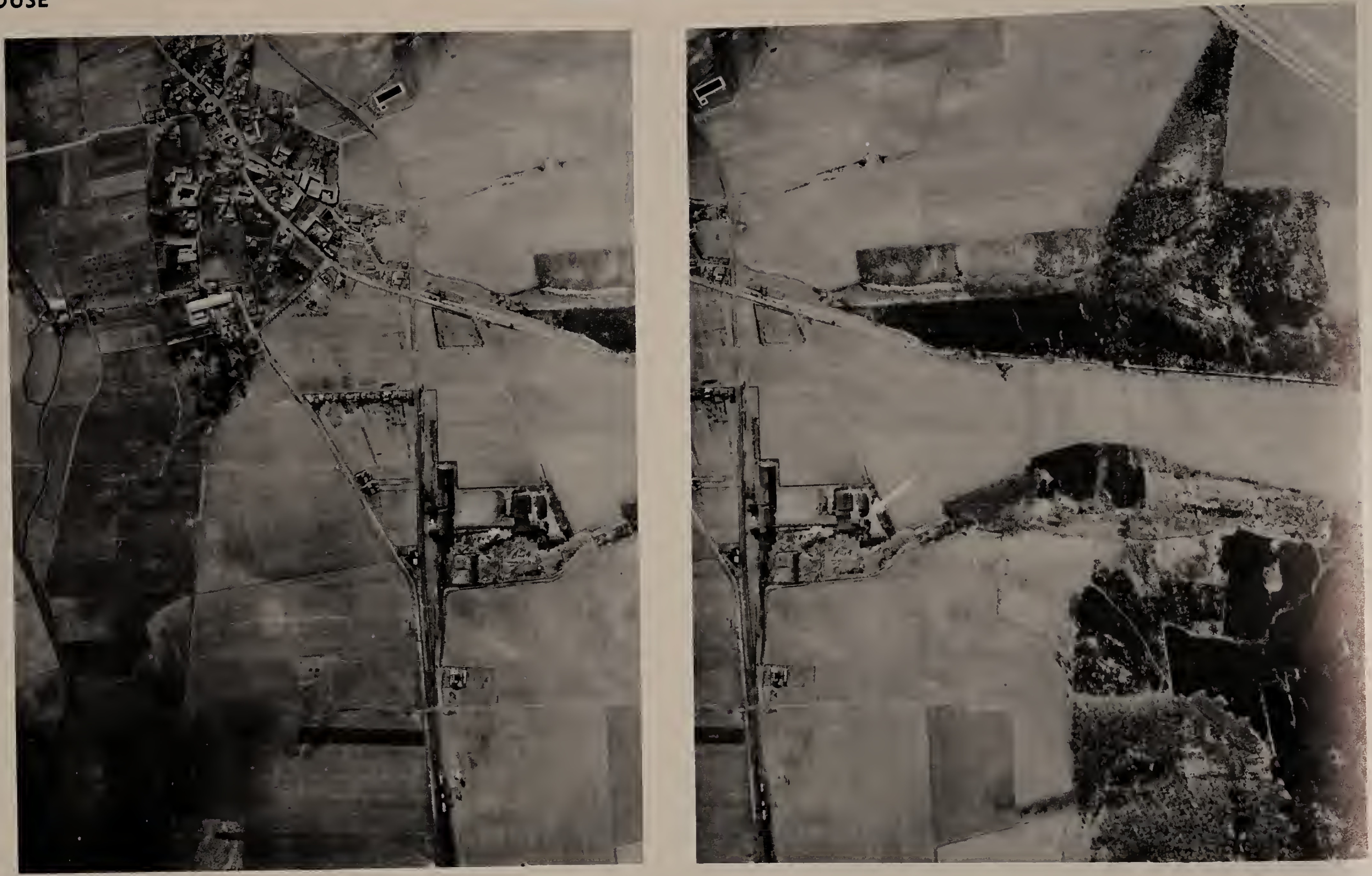


FIGURE 95. Stereogram of salt mine at Morsleben, Soviet Zone, Germany. This mine was entered by a single vertical shaft. Note the appearance of the headframe over the shaft. An underground factory installed in this mine by the Askania Werke of Berlin produced instruments for the V–1 flying bomb, the V–2 rocket, and for aircraft. The factory occupied 323,000 square feet of floor space in the mine and employed 4,000 workers. The mine continued to produce salt. It is not known if the underground factory had been installed when the above photographs were taken.

Cover: Prints 4051–4052 of Sortie J/777, dated 31 March 1944.

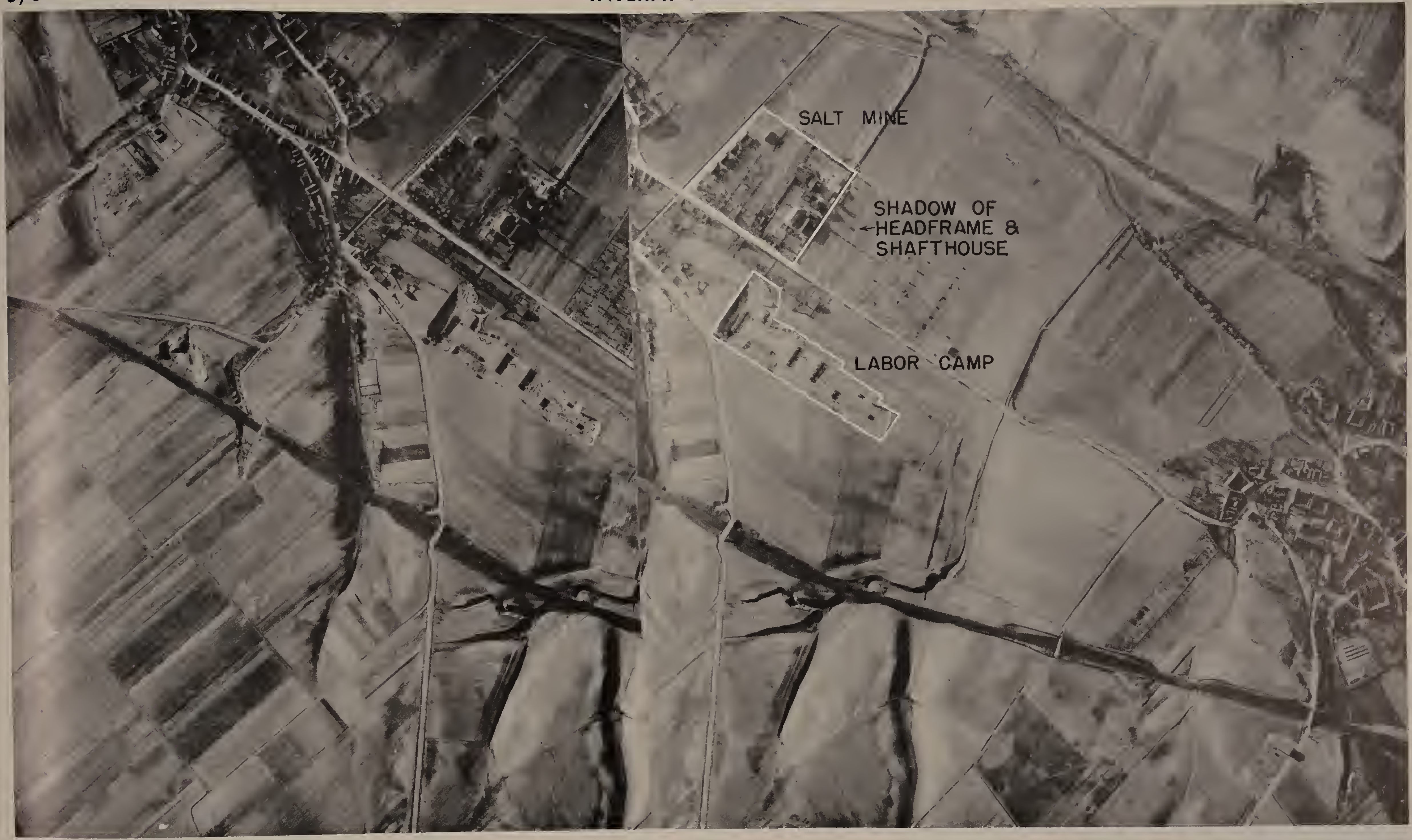


FIGURE 96. Stereogram of salt mine at Gross Schierstedt, Soviet Zone, Germany. Note the shadow of the headframe and shaft house. This mine was entered by a single shaft 1200 feet deep. A Junkers underground factory was installed in this mine. Operations began in May 1943. About 700 persons were employed including slave labor. Tail fuselage assemblies for the Ju 88 and Ju 188 aircraft were produced at the rate of 18–20 per day. The assembly of Panzerfaust also was carried out here. The labor camp across the road from the mine is the main indication that a factory had been installed in this mine. The presence of the headframe, the aerial tramway and associated buildings indicate the presence of the mine.

Cover: Prints 3098–3099 of Sortie 106G/4948, dated 20 March 1945.

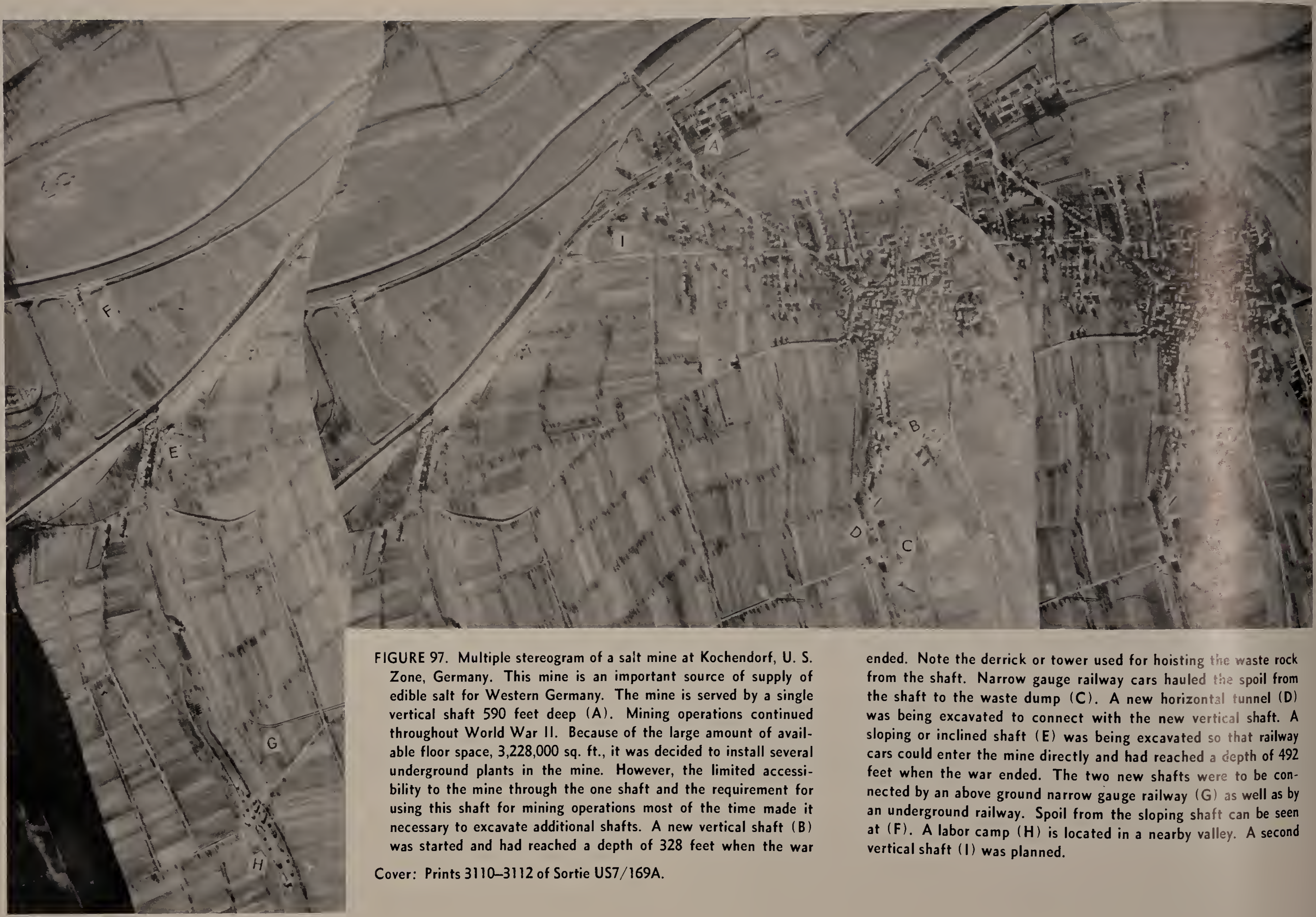


FIGURE 97. Multiple stereogram of a salt mine at Kochendorf, U. S. Zone, Germany. This mine is an important source of supply of edible salt for Western Germany. The mine is served by a single vertical shaft 590 feet deep (A). Mining operations continued throughout World War II. Because of the large amount of available floor space, 3,228,000 sq. ft., it was decided to install several underground plants in the mine. However, the limited accessibility to the mine through the one shaft and the requirement for using this shaft for mining operations most of the time made it necessary to excavate additional shafts. A new vertical shaft (B) was started and had reached a depth of 328 feet when the war ended. Note the derrick or tower used for hoisting the waste rock from the shaft. Narrow gauge railway cars hauled the spoil from the shaft to the waste dump (C). A new horizontal tunnel (D) was being excavated to connect with the new vertical shaft. A sloping or inclined shaft (E) was being excavated so that railway cars could enter the mine directly and had reached a depth of 492 feet when the war ended. The two new shafts were to be connected by an above ground narrow gauge railway (G) as well as by an underground railway. Spoil from the sloping shaft can be seen at (F). A labor camp (H) is located in a nearby valley. A second vertical shaft (I) was planned.

Cover: Prints 3110–3112 of Sortie US7/169A.

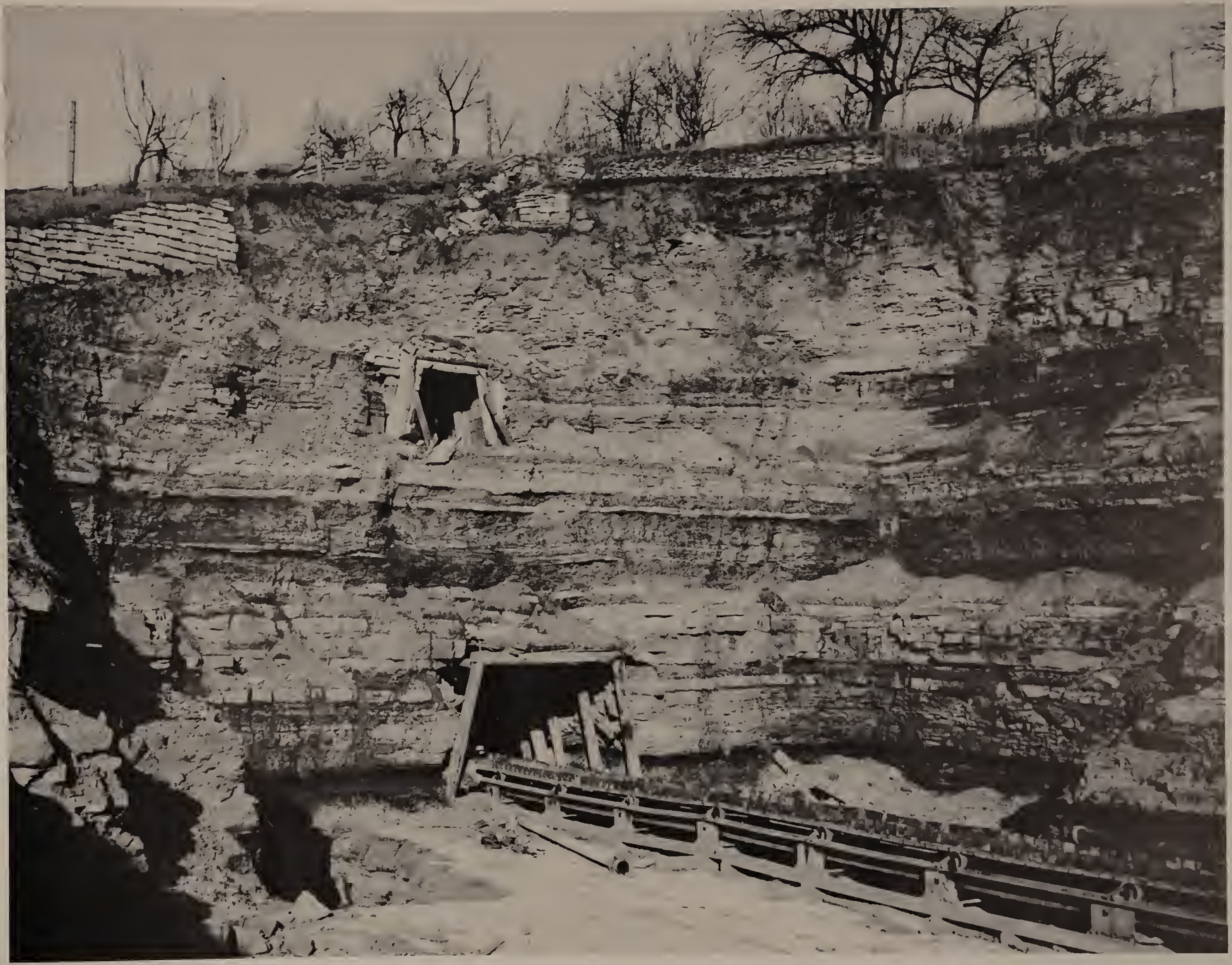


FIGURE 98. View of the new sloping shaft under construction in 1945 at the salt mine at Kochendorf, U. S. Zone, Germany. An aerial view of this excavation is shown in Fig. 97. Note the utilization of a belt conveyor for the removal of spoil from the tunnel. Photo by A–2, USAFE, 1946.

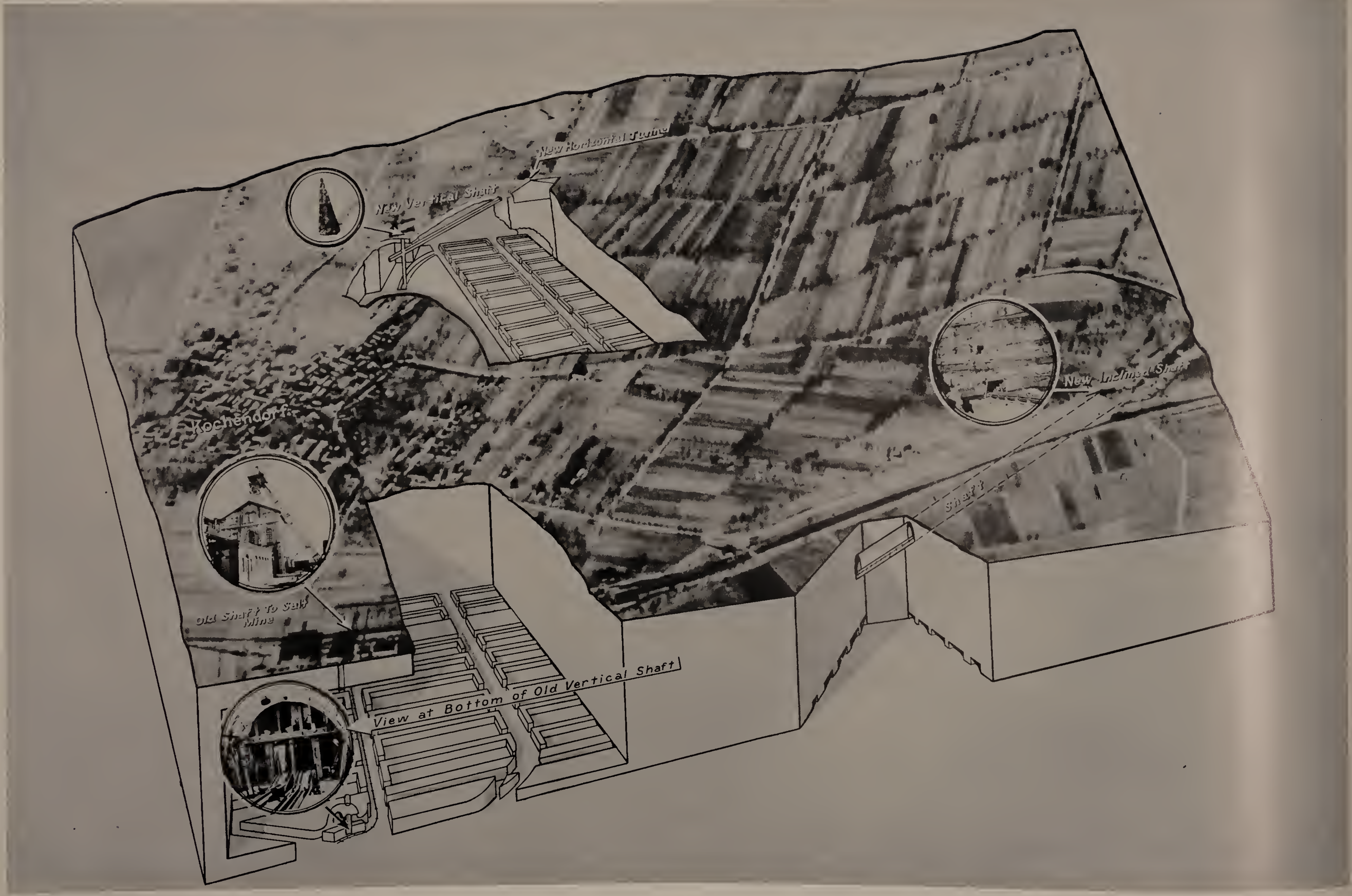


FIGURE 99. Perspective cutaway drawing of the salt mine at Kochendorf, U. S. Zone, Germany.

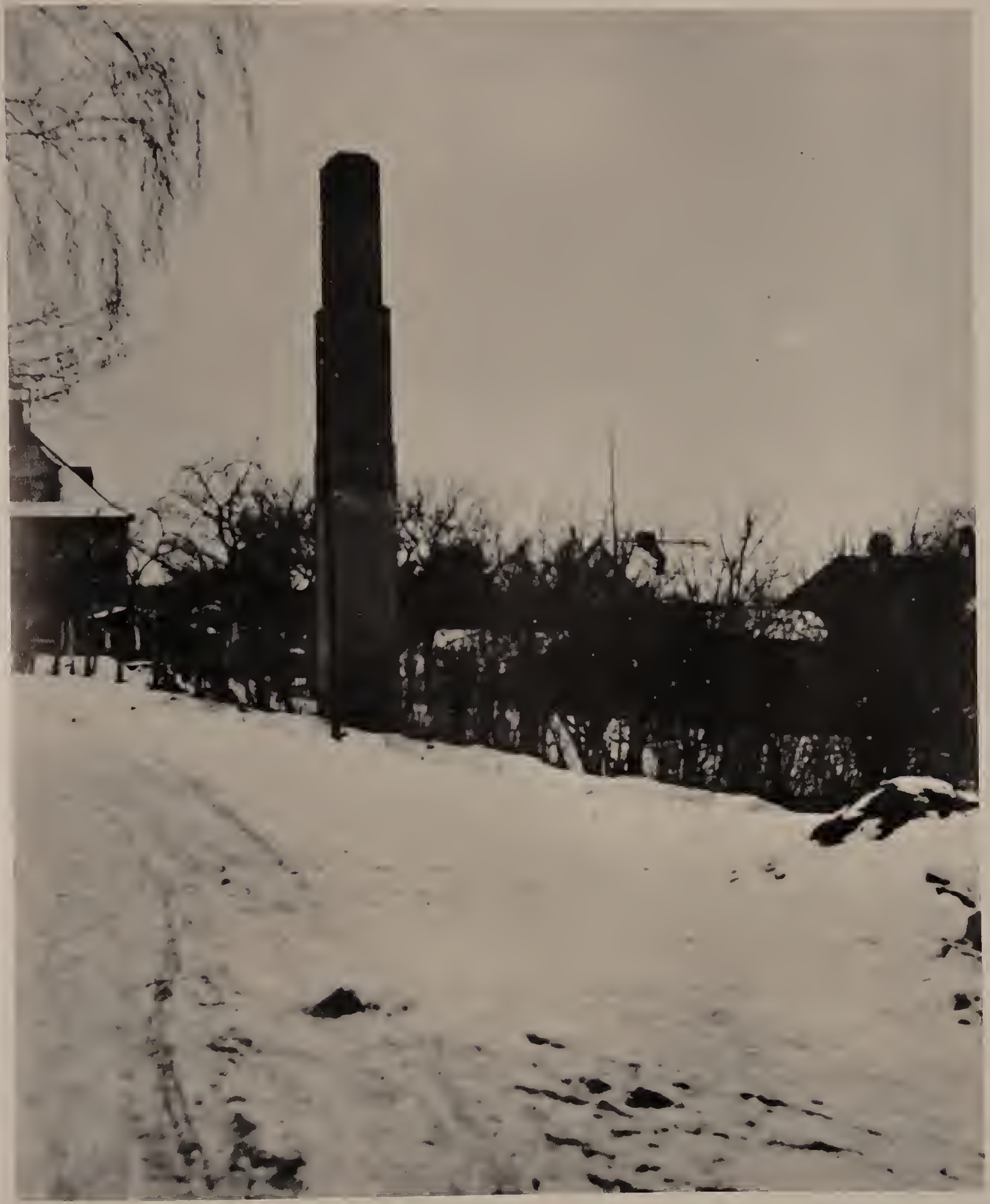


FIGURE 100. Smoke stack protruding from the ground at the Aluminiumwerke underground plant at Ansbach, U. S. Zone, Germany. Directly beneath this smoke stack were coal fired boilers used for supplying hot water for the heating system. Photo by A–2, USAFE, 1946.

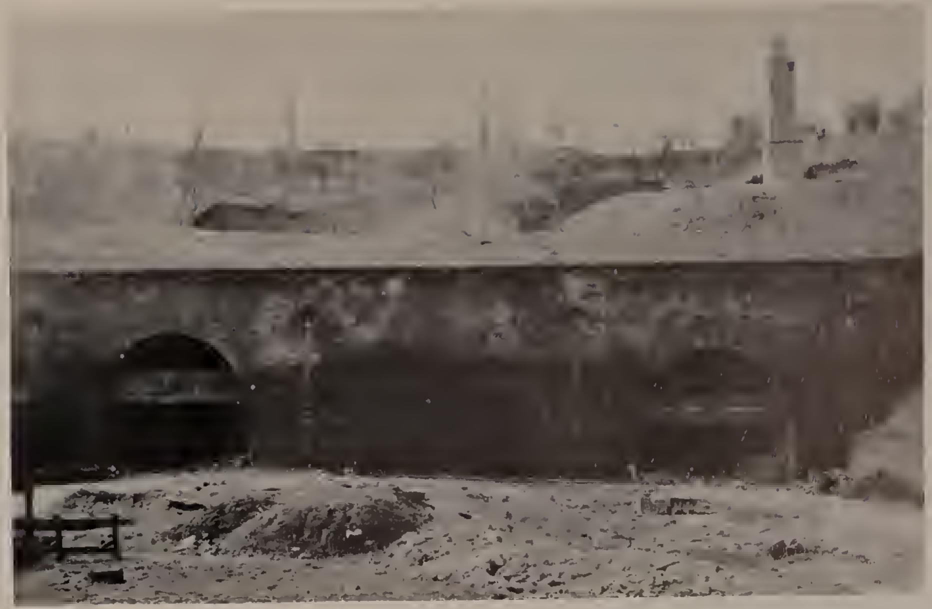


FIGURE 101. Smoke stack for a heating plant at the Messerschmitt underground factory in twin autobahn tunnels at Leonberg, U. S. Zone, Germany. An aerial view of this smoke stack is shown in Figure 102. This underground plant produced complete wings for the Me 262 jet fighter aircraft at the rate of 400 a month. Photo by A–2, USAFE, 1946.

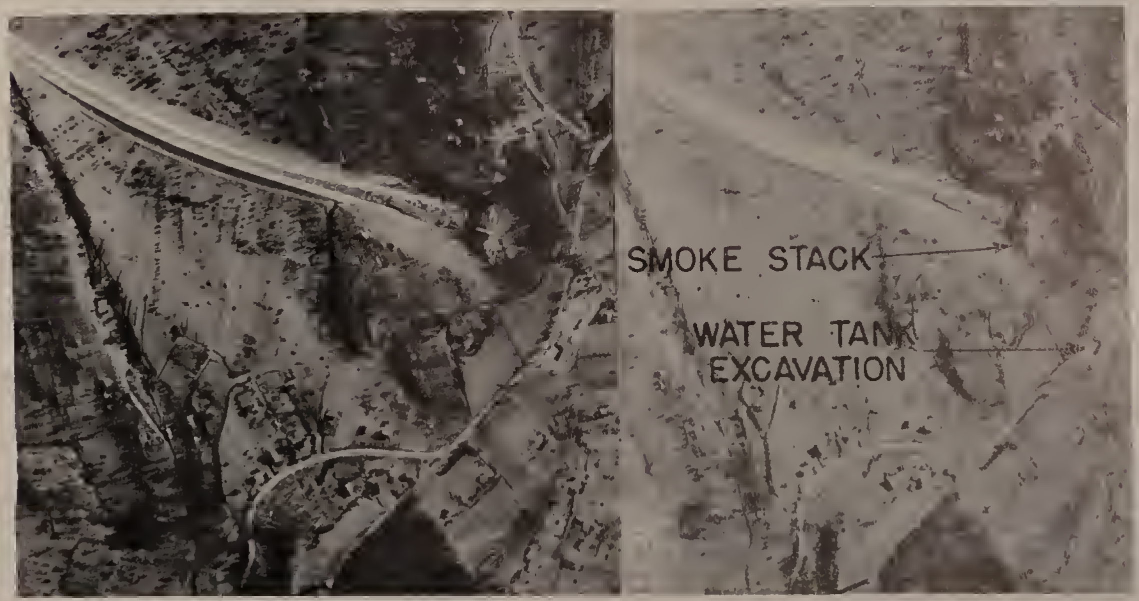
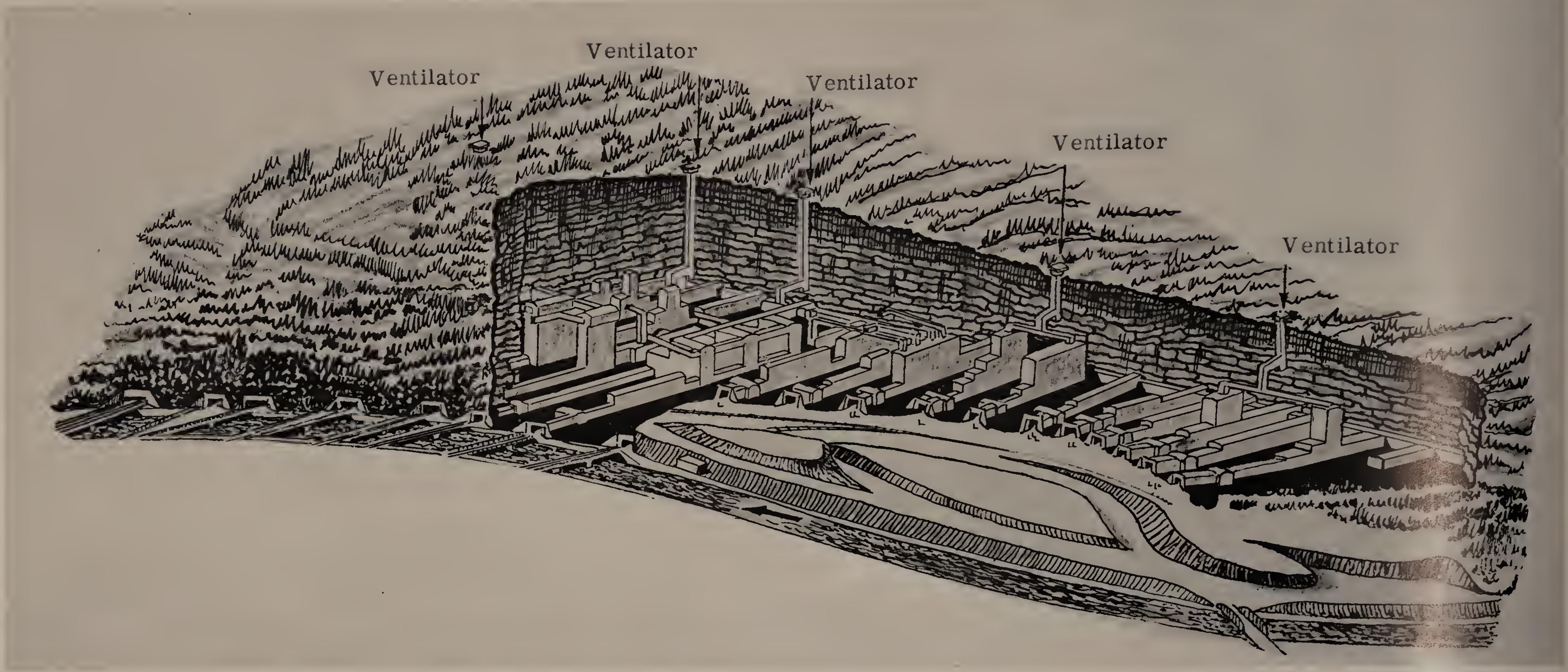


FIGURE 102. Stereogram of the smoke stack at the Messerschmitt underground plant at Leonberg, U. S. Zone, Germany shown in Fig. 101. Note the small waste dump, formed when the smoke shaft was being excavated, and the scaffolding used during the construction of the chimney.

Cover: Prints 3007–3008 of Sortie 32S/797.



CUTAWAY DRAWING OF PROPOSED UNDERGROUND HYDROGENATION PLANT AT HEGGEN, NEAR FINNENTROP, GERMANY.
BERGIUS PROCESS DESIGNED TO PRODUCE 10,000 TONS OF AVIATION GASOLINE PER MONTH.

FIGURE 103. This proposed underground hydrogenation plant was to have been built in entirely new tunnels specially designed for the plant. The site selected for the excavation was a pre-existing quarry on the River Bigge three miles northeast of Attendorn, British Zone, Germany. Note the five vertical ventilation shafts. The tops of these were to have been protected by massive concrte slabs. There were also to have been seven sloping ventilation shafts emerging either from the quarry face or from the side of the hill. There were to have been 20 tunnel entrances one of which, not shown, would have been the entrance to a standard gauge railway tunnel extending across the entire rear of the plant. A floor space of 420,000 sq. ft. was planned. The site had been cleared and the excavation of the tunnels was about to begin when the war ended. The above drawing is based on an original German drawing.

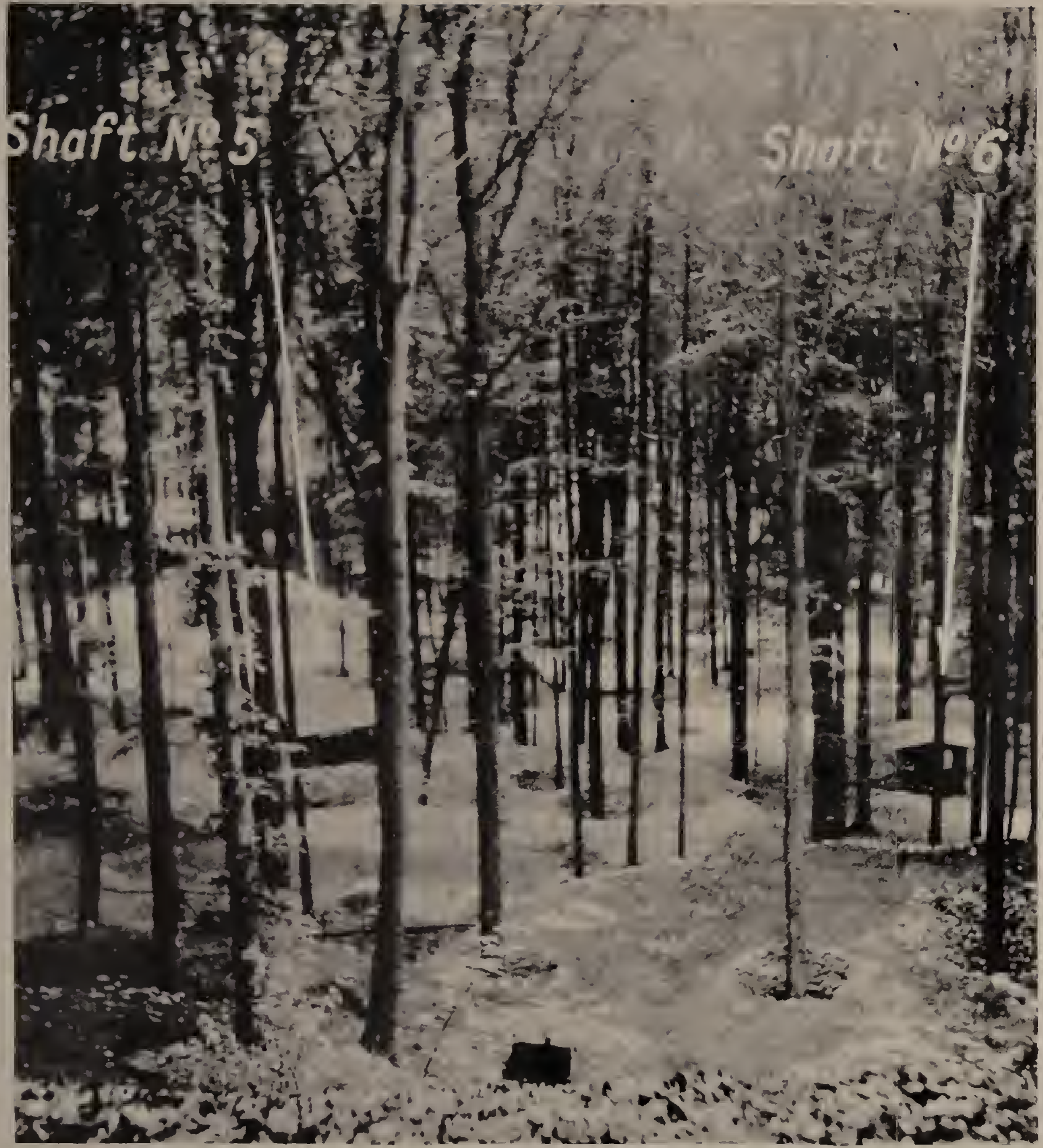
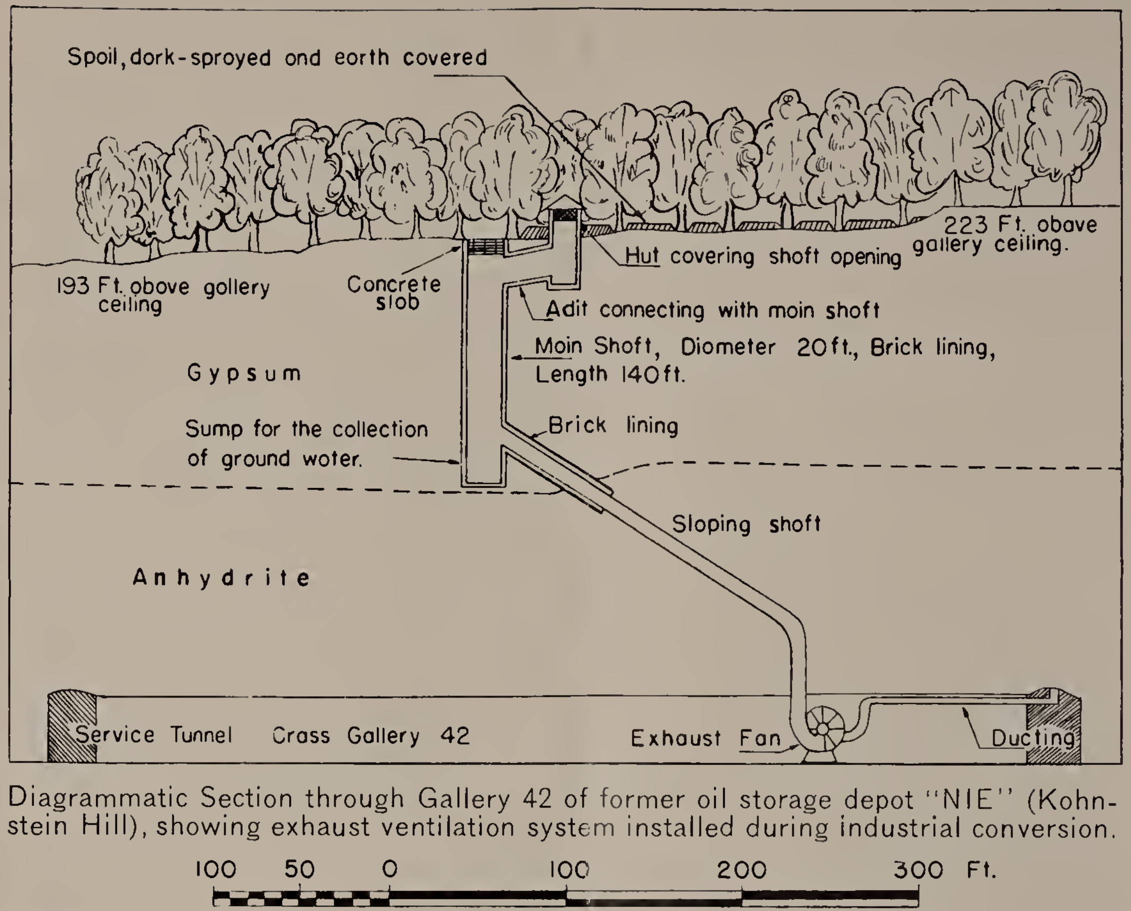
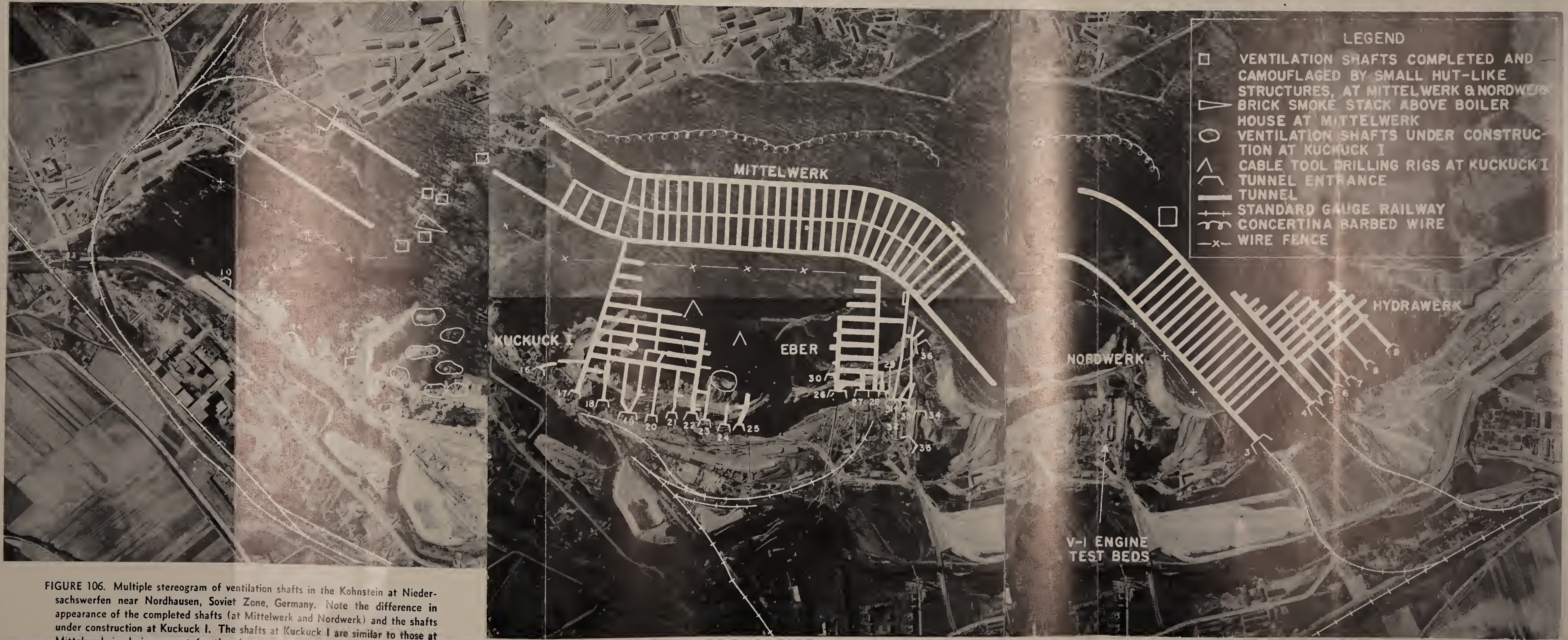


FIGURE 104. Typical hut-like wooden structures built over the ventilation shafts at Mittelwerk, the underground V–1 and V–2 factory at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. Note that the spoil removed during the excavation of the shafts was dumped nearby, camouflaged with dirt and paint, and that tree wells were built in order to prevent the trees from being killed. On aerial photographs these tree wells have the appearance of small circular pits. Note their appearance in Figure 106. A cross section of a typical ventilation shaft at Mittelwerk is shown in Figure 105. Photo by Capt. G. F. D. McBride, CIOS Team 163, June 1945. AF Neg. No. 276565.


Spoil, dark-sprayed and earth covered
223 Ft. above gallery ceiling.
Hut covering shaft opening
193 Ft. above gallery ceiling
Concrete slab
Adit connecting with main shaft
Main Shaft, Diameter 20ft., Brick lining, Length 140ft.
Gypsum
Sump for the collection of ground water.
Brick lining
Sloping shaft
Anhydrite
Service Tunnel
Cross Gallery 42
Exhaust Fan
Ducting
100 50 0 100 200 300 Ft.

Diagrammatic Section through Gallery 42 of former oil storage depot "NIE" (Kohnstein Hill), showing exhaust ventilation system installed during industrial conversion.

FIGURE 105. Diagrammatic cross section of a typical ventilation shaft at Mittelwerk, the state-owned V-weapons underground factory at Niedersachswerfen, Soviet Zone, Germany. Note that the small hut-like structure, also shown in Figure 104, is not over the main shaft but is over a secondary shaft which is connected to the main shaft by a short tunnel. Note also that the main vertical shaft is concealed and protected by a thick concrete slab which is flush with the ground. Five of these camouflaged ventilation shafts were present at Mittelwerk and two at Nordwerk. All seven of these as well as a tall brick chimney or smoke stack (over Mittelwerk) are shown in Fig. 106. The huts over the secondary shafts can only be seen on aerial photographs taken during the winter months after the leaves have fallen from the trees. The concrete slabs over the main vertical shafts were concealed by spoil and dirt. All of the secondary shafts and the main vertical shafts were lined with brick, were round and were 20 feet in diameter. Because of the complicated design of this type of ventilation shaft it is impossible to determine from aerial photographs the exact position of the factory tunnels with respect to the ventilation shafts above them.


LEGEND
□ VENTILATION SHAFTS COMPLETED AND CAMOUFLAGED BY SMALL HUT-LIKE STRUCTURES, AT MITTELWERK & NORDWERK
BRICK SMOKE STACK ABOVE BOILER HOUSE AT MITTELWERK
○ VENTILATION SHAFTS UNDER CONSTRUCTION AT KUCKUCK I
Λ CABLE TOOL DRILLING RIGS AT KUCKUCK I
TUNNEL ENTRANCE
TUNNEL
STANDARD GAUGE RAILWAY
CONCERTINA BARBED WIRE
—x— WIRE FENCE
MITTELWERK
KUCKUCK I
EBER
NORDWERK
HYDRAWERK
V-I ENGINE TEST BEDS
10
16
17
18
19
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24
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FIGURE 106. Multiple stereogram of ventilation shafts in the Kohnstein at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. Note the difference in appearance of the completed shafts (at Mittelwerk and Nordwerk) and the shafts under construction at Kuckuck I. The shafts at Kuckuck I are similar to those at Mittelwerk in design except for the absence of the short off-set vertical shaft. The lower part of the shafts were the same. Most of them are 11.8 feet in diameter instead of 20 feet. Note the derrick or tower over some of the shafts, identified by its

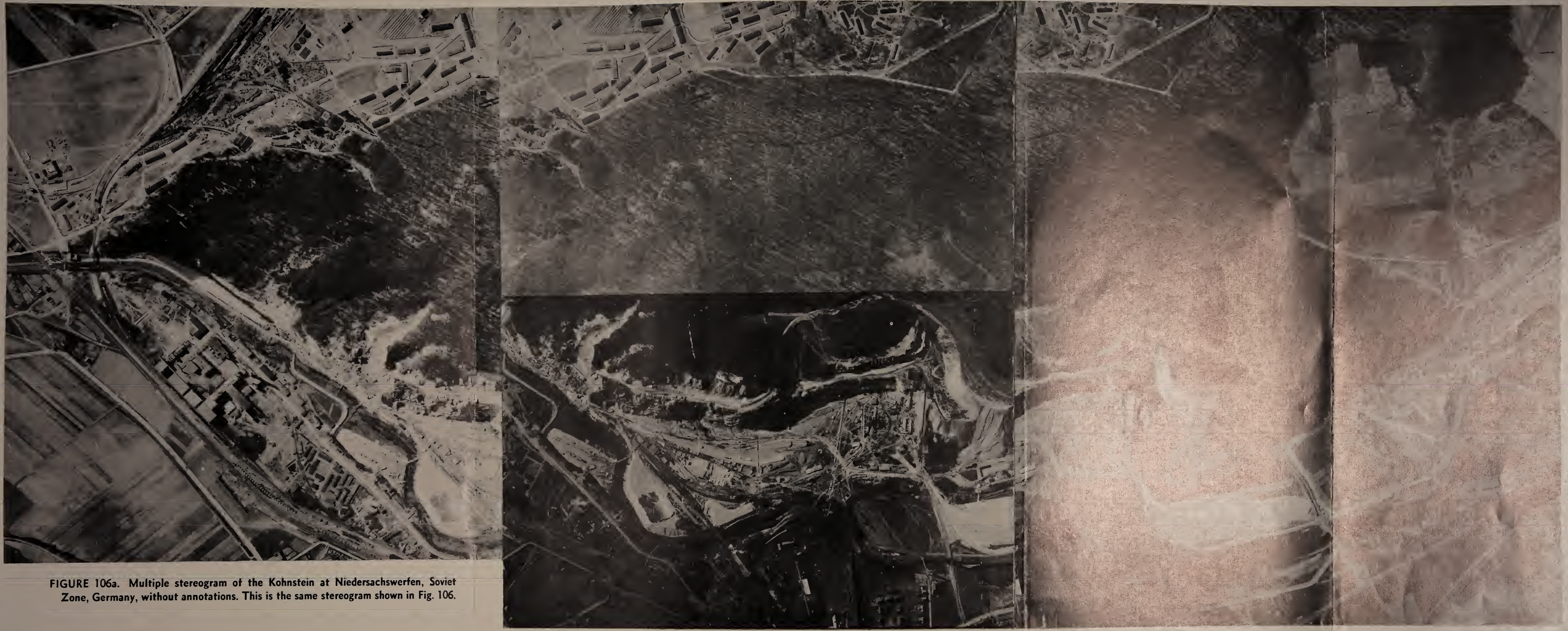


FIGURE 106a. Multiple stereogram of the Kohnstein at Niedersachswerfen, Soviet Zone, Germany, without annotations. This is the same stereogram shown in Fig. 106.

FIGURE 106 (continued)

shadow, and the associated hoist house. These shafts were excavated partly by cable tool drilling rigs and then enlarged by drilling and blasting. The cable tool drilling rigs were similar to those used for drilling oil wells and were powered by a steam engine. Some of the broken rock was removed from the shafts by means of a bucket and steel cable supported by the derrick. Broken rock also was removed by gravity from the bottom of the shaft after the shaft was broken through from the surface. Excavation probably commenced simultaneously at both the bottom and the top of the shaft. Buckets also were used to lower brick and mortar into the shaft for the installation of the brick lining. Electric-motors were used for this hoisting operation. After the lining was completed the derrick and hoist house were removed.

Key to Identification of Tunnel Entrances

1– 2 Entrances to Mittelwerk, a V–1 and V–2 factory.
3– 4 Entrances to Nordwerk, a Junkers aircraft engine factory.
5– 9 Entrances to Hydrawerk, a Junkers jet aircraft engine factory under construction.
10 Explosives storage tunnel. Entrance tunnel 3.5 ft. wide and 12 ft. long leading to underground room 10 ft. wide and 12 ft. long.
11 New tunnel 10 ft. wide and 70 ft. long leading to room 40 ft. long and 35 ft. wide, and approximately 35 ft. high, purpose unknown. Entrance fitted with wooden door.
12–13 Two tunnels 12 ft. wide and 50 ft. long leading into a room 85 ft. by 150 ft. and approximately 35 ft. high. Above each tunnel was an opening or window which on the photograph has the appearance of a higher level tunnel. This room was being built for an underground transformer station.
14 WIFO air raid shelter 15 ft. by 100 ft.
15 Old tunnel 10 ft. wide and 115 ft. long, two entrances, used for dynamite storage. Small room at end of tunnel fitted with iron door.
16–25 Entrances to Kuckuck I, an underground hydrogenation plant under construction. Note turntables for standard gauge railway cars at entrances 17–19.
26–29 Entrances to Eber, an underground liquid oxygen plant under construction.
30 New tunnel, shaft in floor connects with Eber below.
31 Tunnel excavated for removal of spoil when WIFO oil storage tunnels were excavated, later occupied by Nordwerk.
32–33 Old tunnels related to the commercial quarrying operations on the bench or upper quarry. A rock crusher and storage bin were located beneath the square building at the top of the cliff. Loading bins beneath the storage bin opened into tunnel 33.
34–35 Old tunnels used for storage of oil drums. Reported to have been excavated in World War I. A short branch of tunnel 34 emerged in the face of the cliff. A machine gun position was located in this opening.
36 Two small old tunnels.

Cover: Prints 3112–3114 of Sortie 106G/5105, dated 25 March 1945. Scale 1/8,000.

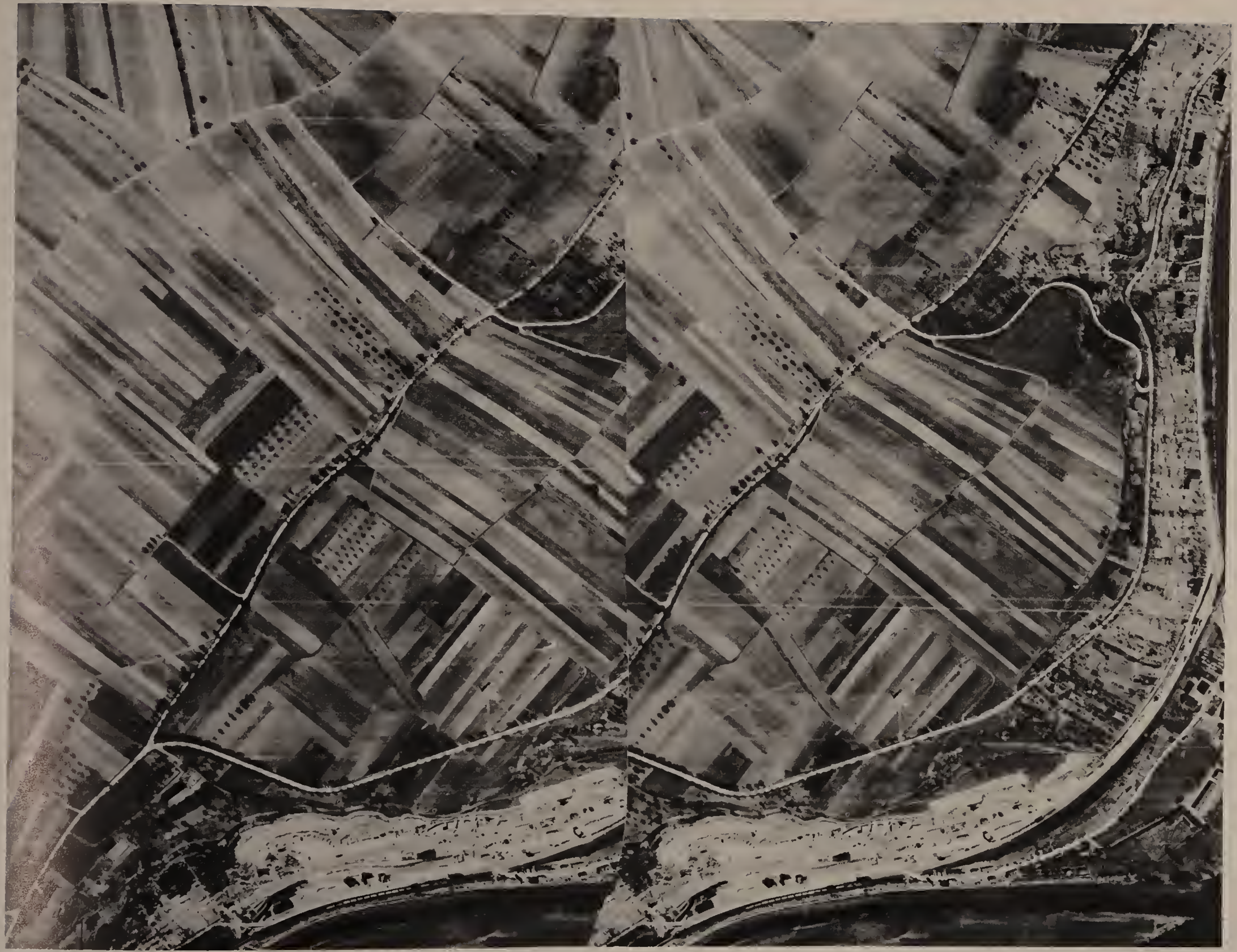


FIGURE 107. Stereogram of a ventilation shaft under construction at the site for a Daimler Benz underground aircraft engine factory at Rottenburg, French Zone, Germany. Note the shadow of the derrick and the power line and paths leading to it. A ground photograph of the derrick, taken about a year later, is shown in Fig. 108. Eight new tunnels, of 25 planned, were being excavated in the steep cliff by the Neckar River. Note the narrow gauge railway track leading into them. Of a total of 312,040 square feet of underground floor space planned approximately 100,000 square feet had been excavated when the war ended. The factory was never installed in the tunnels.

Cover: Prints 4067–4068 of Sortie 106G/5039, dated 23 March 1945. Scale 1/8,500.

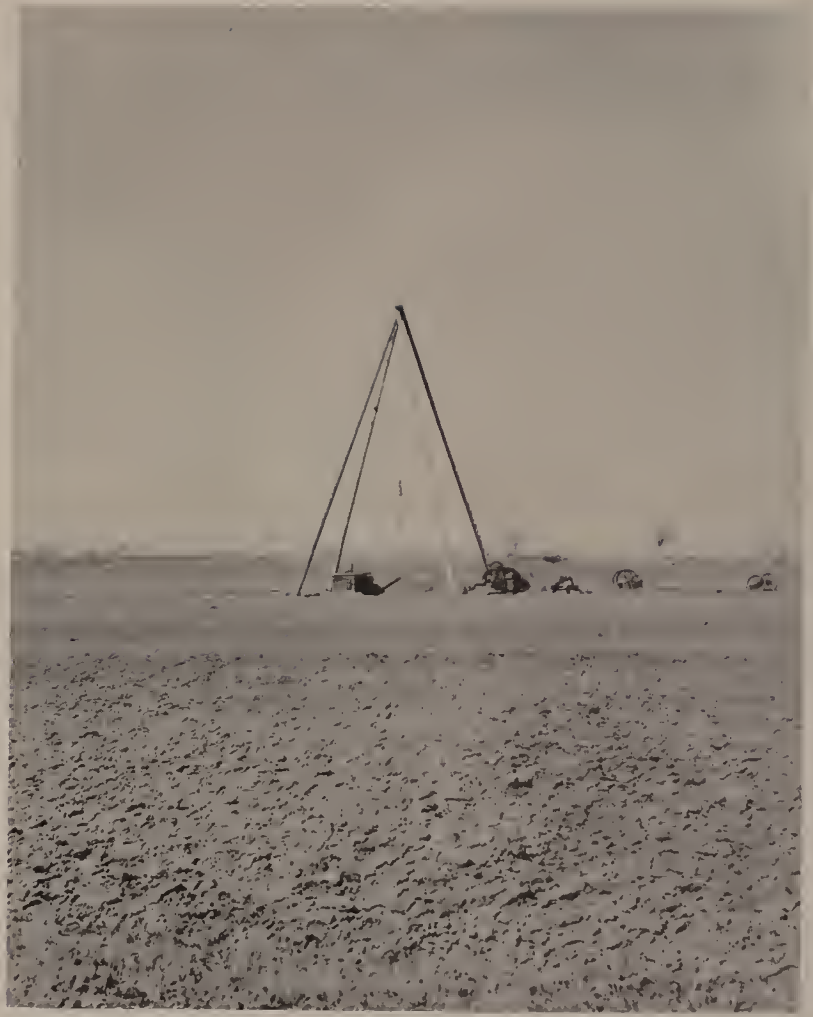


FIGURE 108. Ventilation shaft under construction at the site for a Daimler Benz underground aircraft engine factory at Rottenburg, French Zone, Germany. This shaft was being dug by a small cable tool drilling rig which dug a hole two and a half feet in diameter. An aerial view is shown in Fig. 107. The thickness of the overburden at this site varies from 105 to 165 feet. Photo by A–2, USAFE, April 1946.

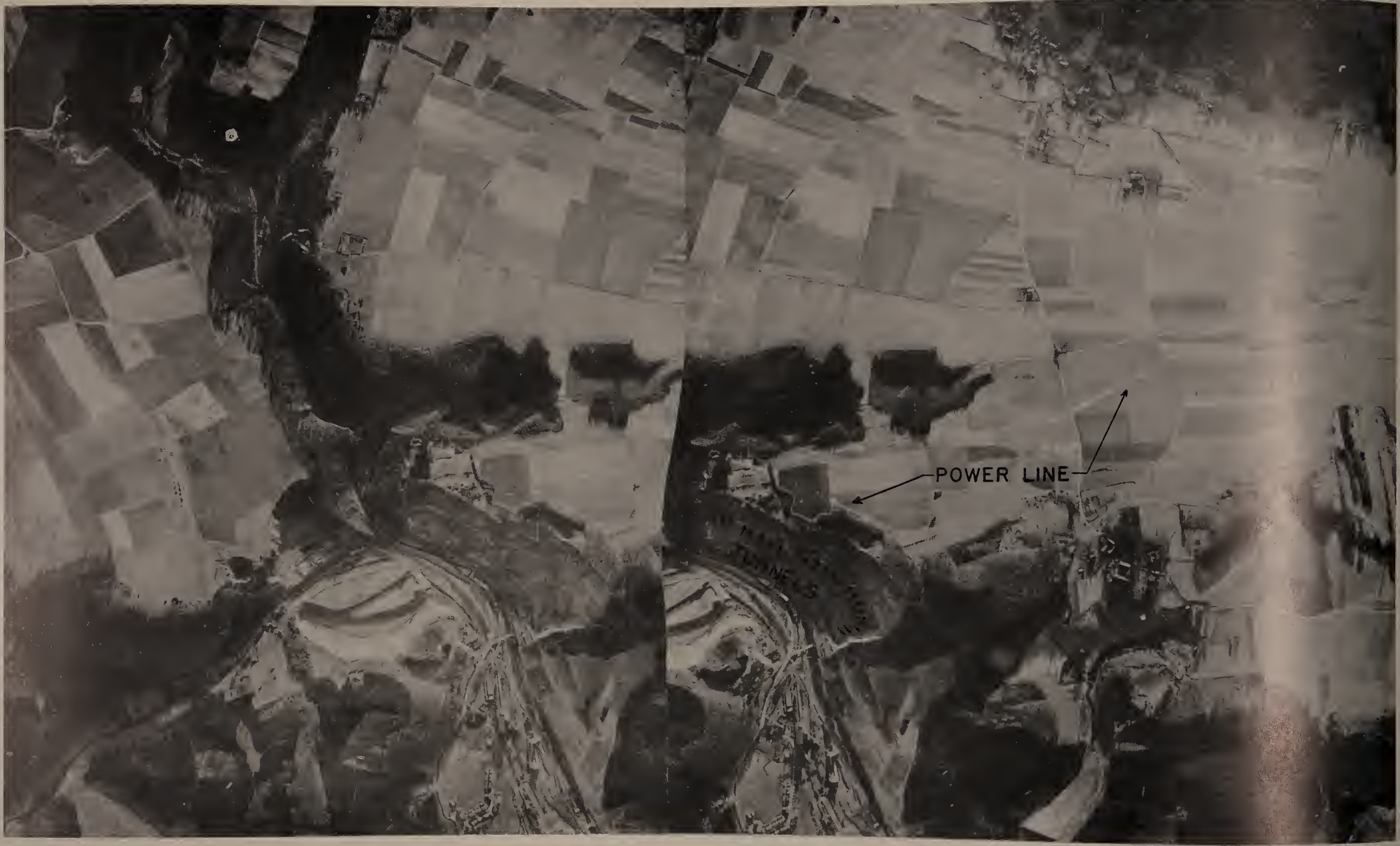


FIGURE 109. Stereogram of new power lines under construction for an underground hydrogenation plant at Oberroedinghausen near Boingsen, Westphalia, British Zone, Germany. This plant, code name Schwalbe I, was designed to produce 10,000 tons of synthetic aviation gasoline a month. Twenty-two new tunnels were being excavated in the cliff of a limestone quarry. Some of the tunnels were 30 feet wide and 70 feet high. The total job called for the excavation of 360,000 cubic yards of rock of which 200,000 cubic yards had been completed when the war ended. The planned floor space was approximately 300,000 square feet.

Cover: Prints 3043–3044 of Sortie 16/521, dated 25 December 1944.

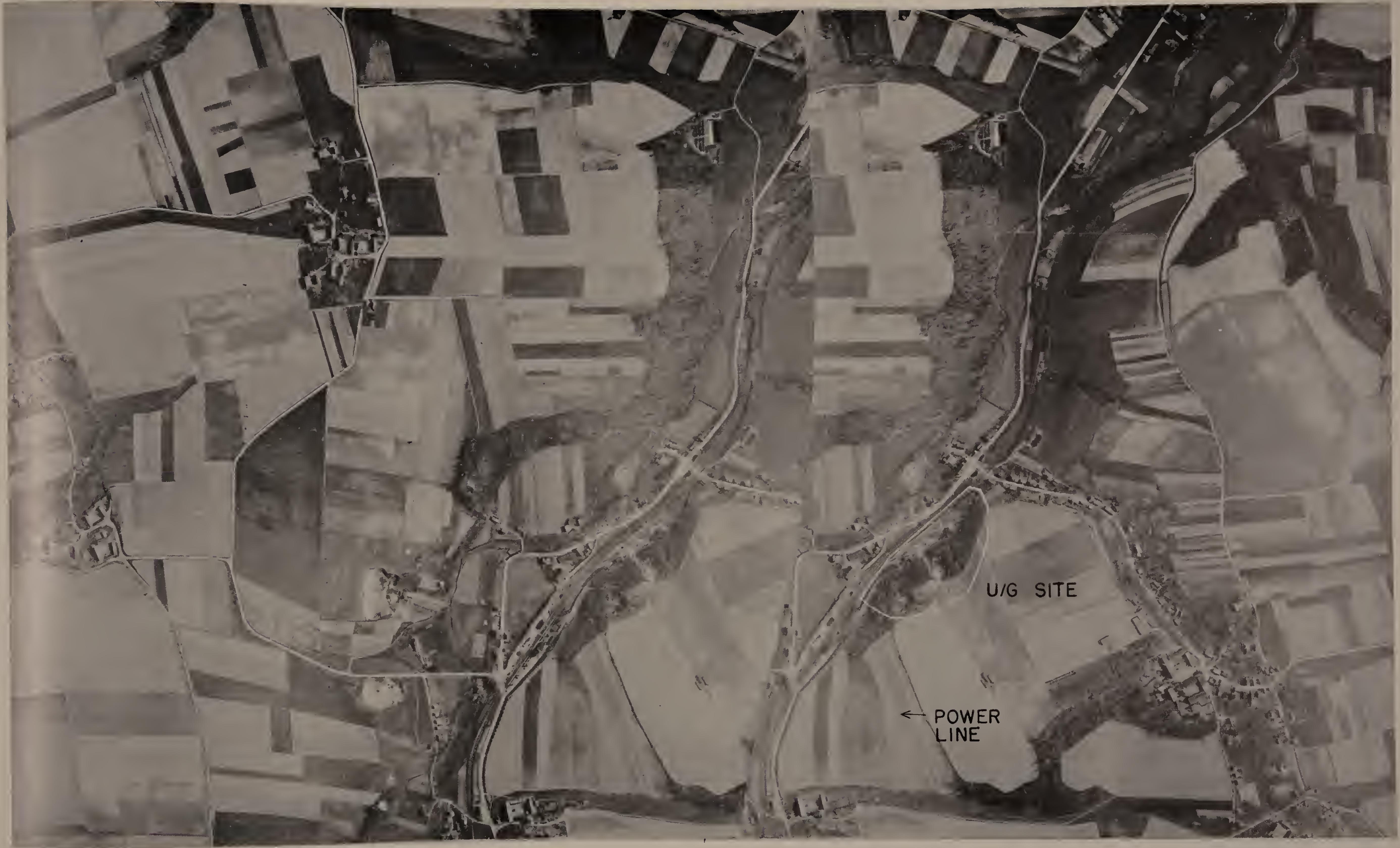


FIGURE 110. Stereogram of new power line under construction for an underground oil plant at Miltitz, Soviet Zone, Germany. This plant, code name Molch 4, was being built for I. G. Farben in an extension of existing tunnels and was designed to produce 3,900 metric tons of diesel oil and 2,500 metric tons of fuel oil per month. The plant was not completed when the war ended.

Cover: Prints 3039–3040 of Sortie U.S. 7/136–13.

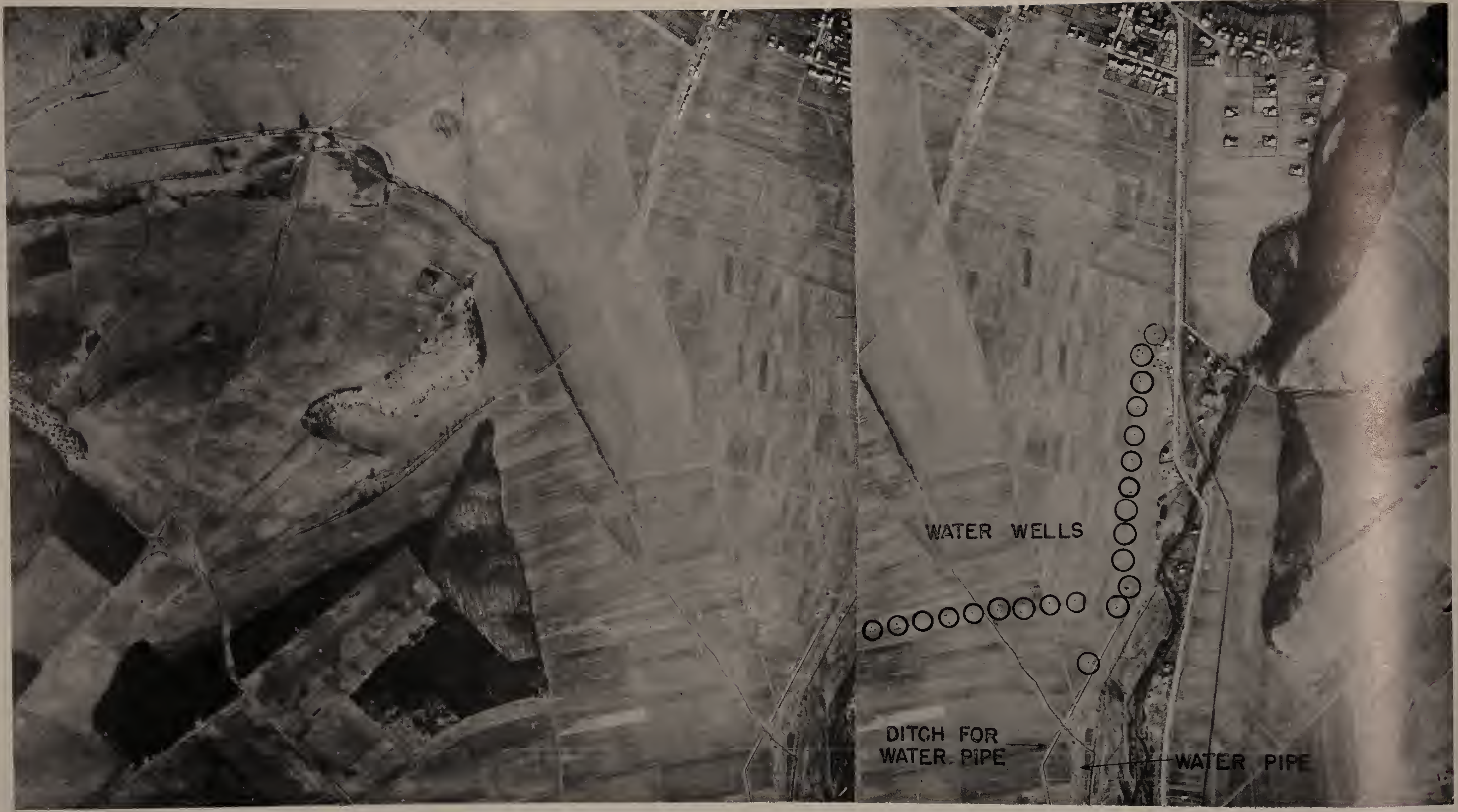


FIGURE 111. Stereogram of water wells and water pipelines under construction for the underground industrial complex known as Mittelbau, at and near Niedersachswerfen, Soviet Zone, Germany. Mittelbau comprised seven underground installations in the Niedersachswerfen area, all of the hillside tunnel-type and all under construction at the end of World War II. This vast underground complex would have had a total floor space of 6,500,000 square feet when completed. Mittelbau included the guided missile factory in the Himmelberg at Woffleben, the Junkers aircraft engine factory in the Muhlberg at Niedersachswerfen, the Junkers aircraft components factory at Stempeda near Rottleberode, the synthetic oil storage depot Kuckuck II at Ellrich and the three following installations in the Kohnstein at Niedersachswerfen: the liquid oxygen plant Eber, the hydrogenation plant Kuckuck I, and the Junkers jet aircraft engine factory Hydrawerk. The water wells shown above were only one of several sources of water for Mittelbau.

Cover: Prints 4209–4210 of Sortie 106G/4779, dated 14 March 1945.

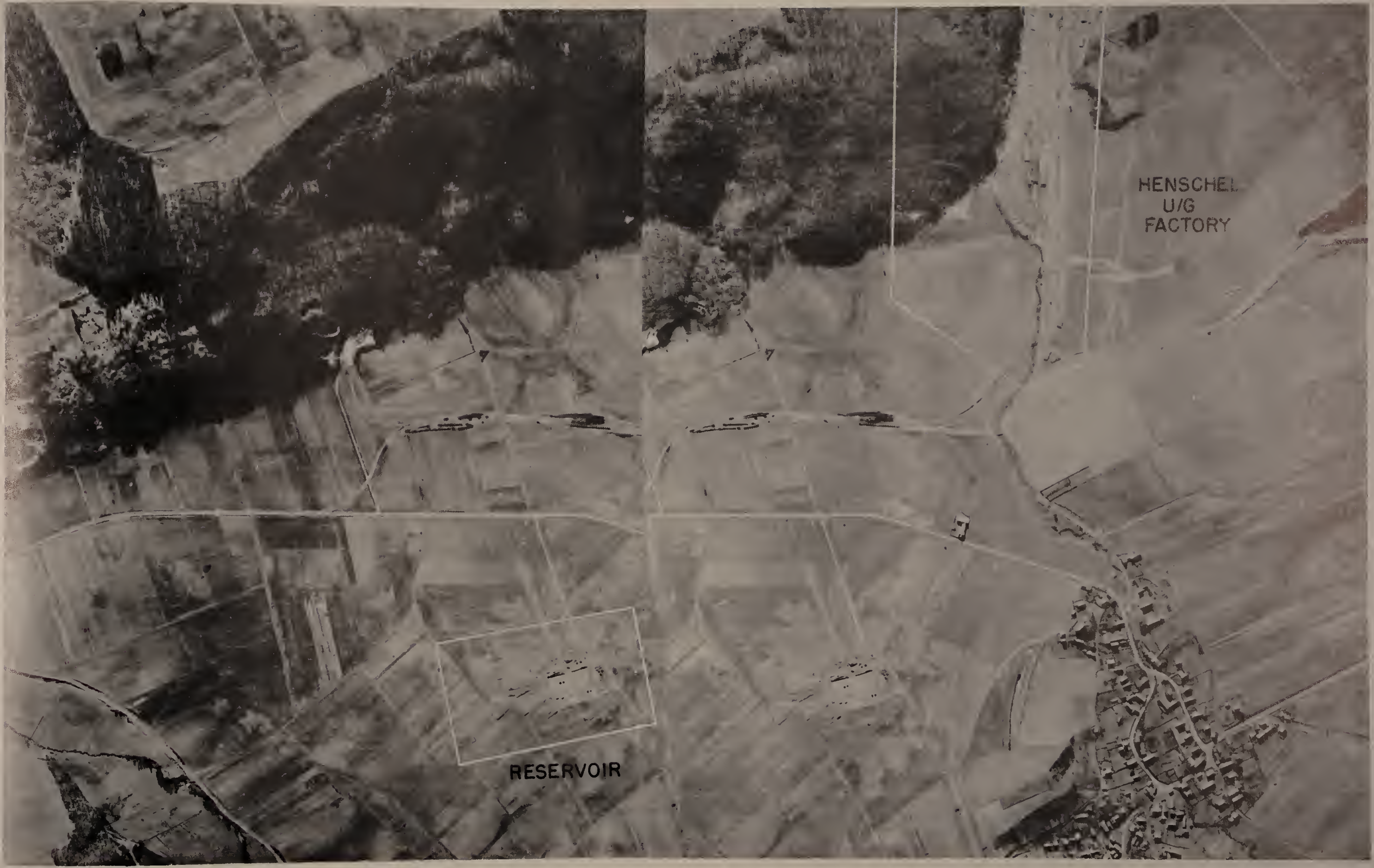


FIGURE 112. Stereogram of one of two reservoirs under construction for the Henschel underground guided missile factory at Wofflben, Soviet Zone, Germany. This factory was part of the Mittelbau project.

Cover: Prints 3213–3214 of Sortie 106G/4779, dated 14 March 1945.

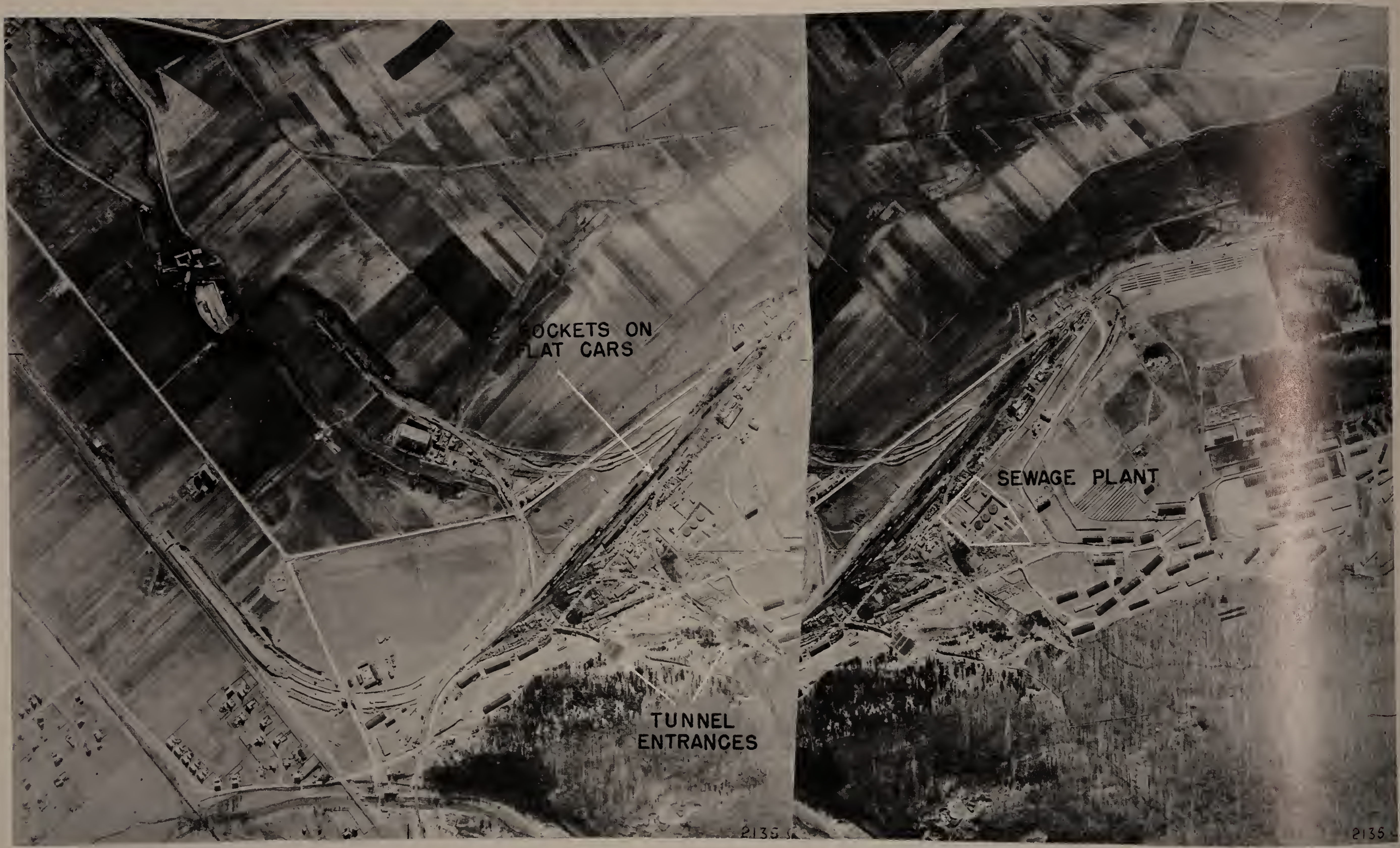


FIGURE 113. Stereogram of sewage plant at Mittelwerk, the underground V–1 and V–2 factory at Niedersachswerfen, near Nordhausen, Soviet Zone, Germany.

Cover: Prints 4205–4206 of Sortie 106G/4779, dated 14 March 1945.

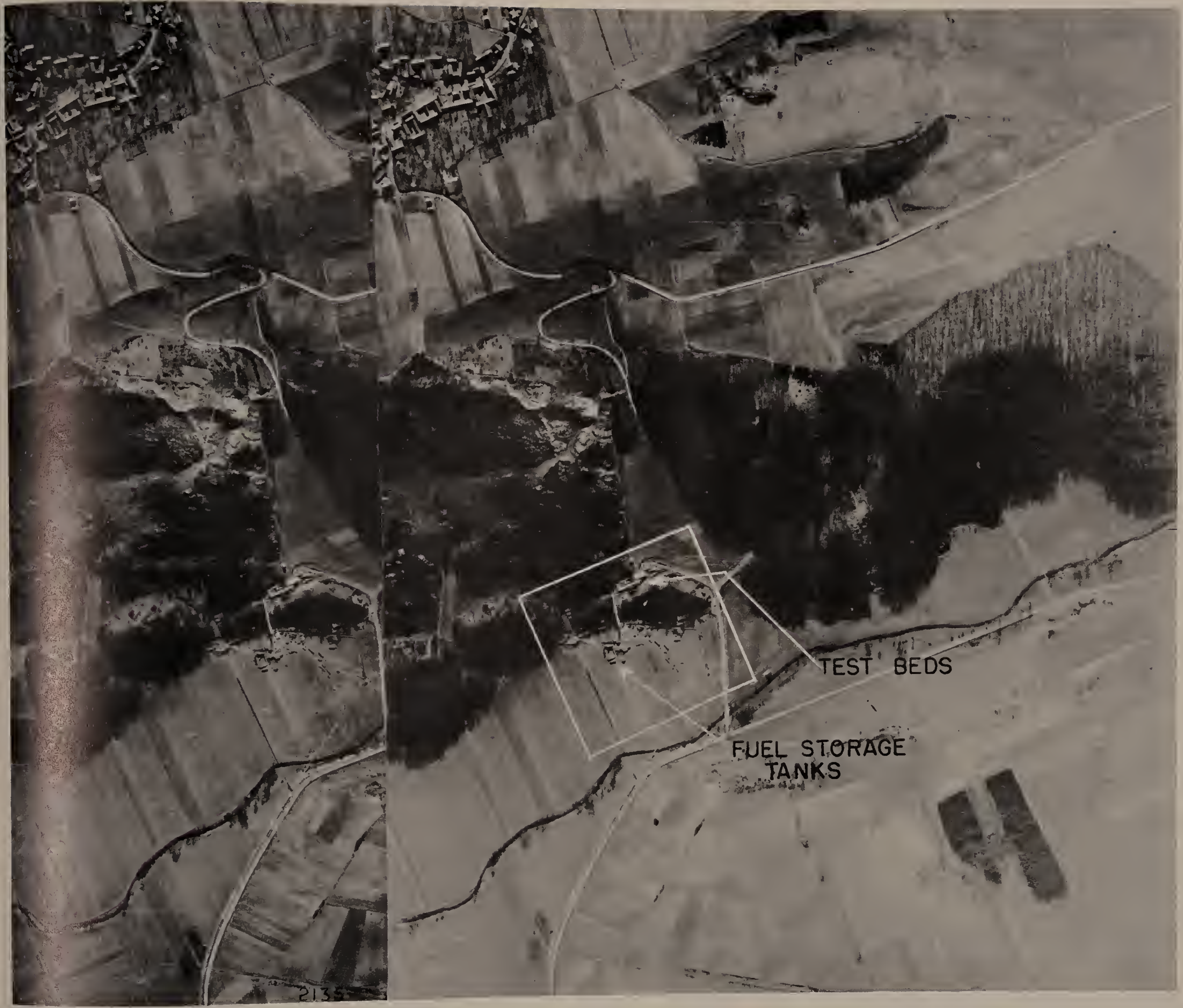


FIGURE 114. Stereogram of jet engine test beds under construction just East of the Junkers underground jet aircraft engine factory Hydrawerk at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. V–1 engine test beds are shown in Figure 106.

Cover: Prints 4200–4201 of Sortie 106G/4779, dated 14 March 1945.

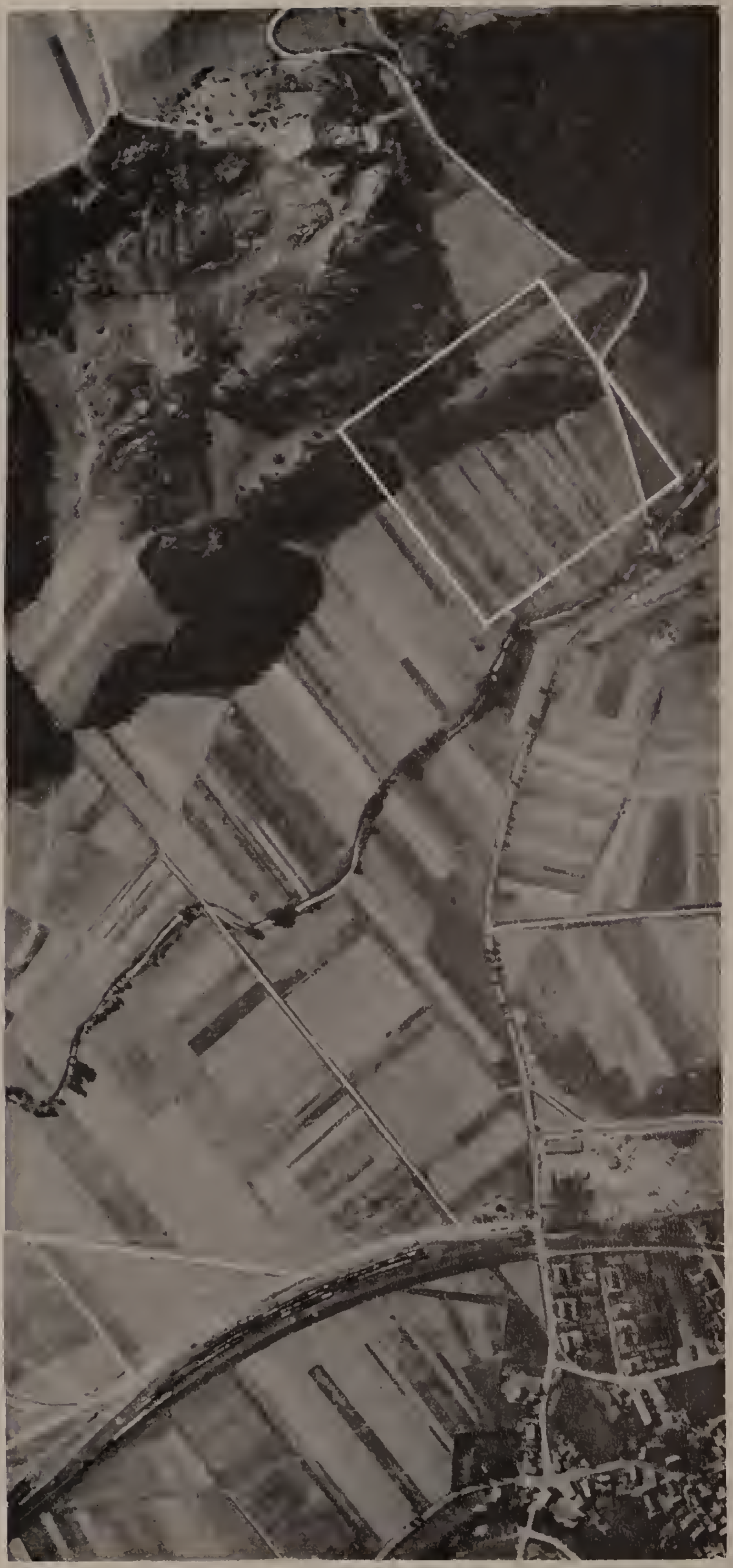


FIGURE 115. Aerial photograph taken prior to construction of test beds shown in Fig. 114 at Niedersachswerfen, Soviet Zone, Germany.

Cover: Print 3020 of Sortie 106G/2413, dated 14 September 1944. Scale 1/9,900.

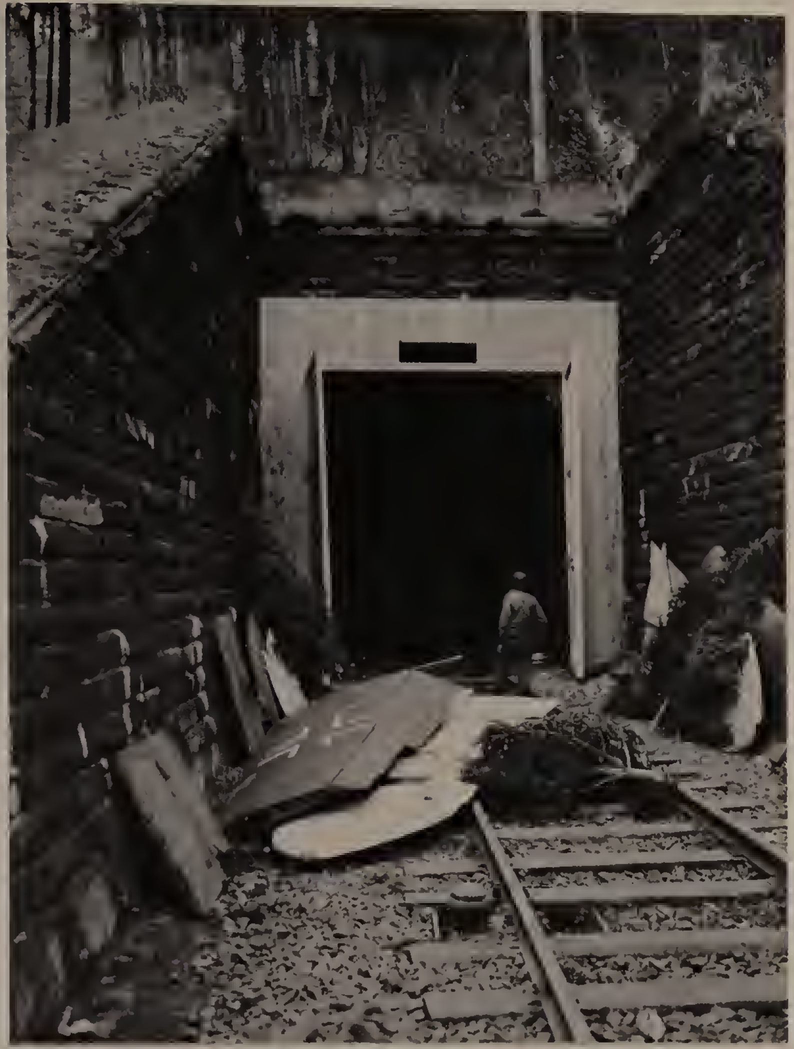


FIGURE 116. Aircraft wings at entrance to underground aircraft wing assembly plant in a railway tunnel near Wertheim, U. S. Zone, Germany. Fighter aircraft were assembled in woods on outskirts of Wertheim. U. S. Army Photograph No. ETO–Hq.–45–30062, dated 2 April 1945.

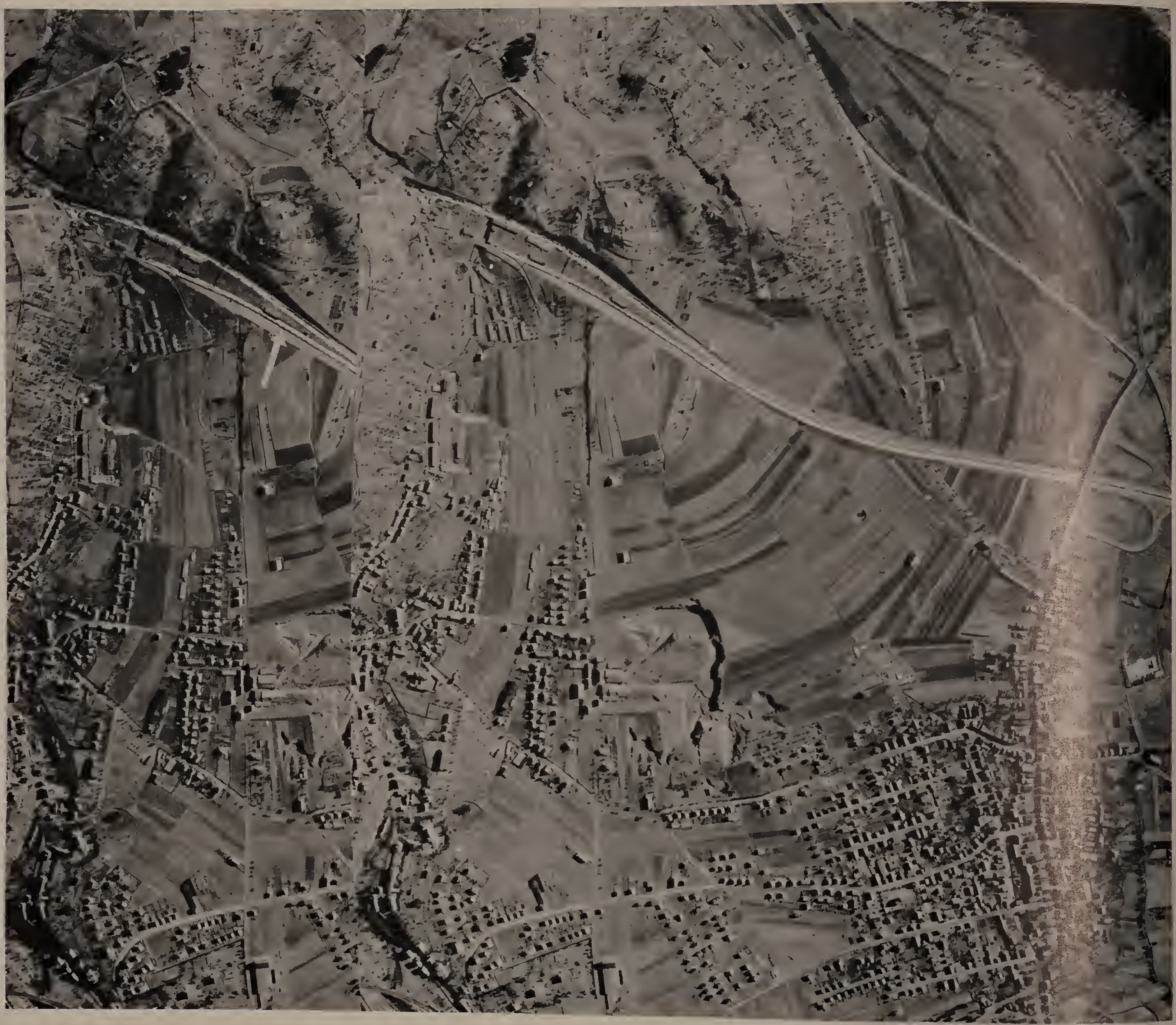


FIGURE 117. Stereogram of ME 262 jet aircraft wings parked along highway opposite entrance to Messerschmitt underground factory in twin autobahn tunnels at Leonberg near Stuttgart, U. S. Zone, Germany. This factory assembled ME 262 wings and also produced some wing parts.

Cover: Prints 3007–3008 of Sortie 32S/797.

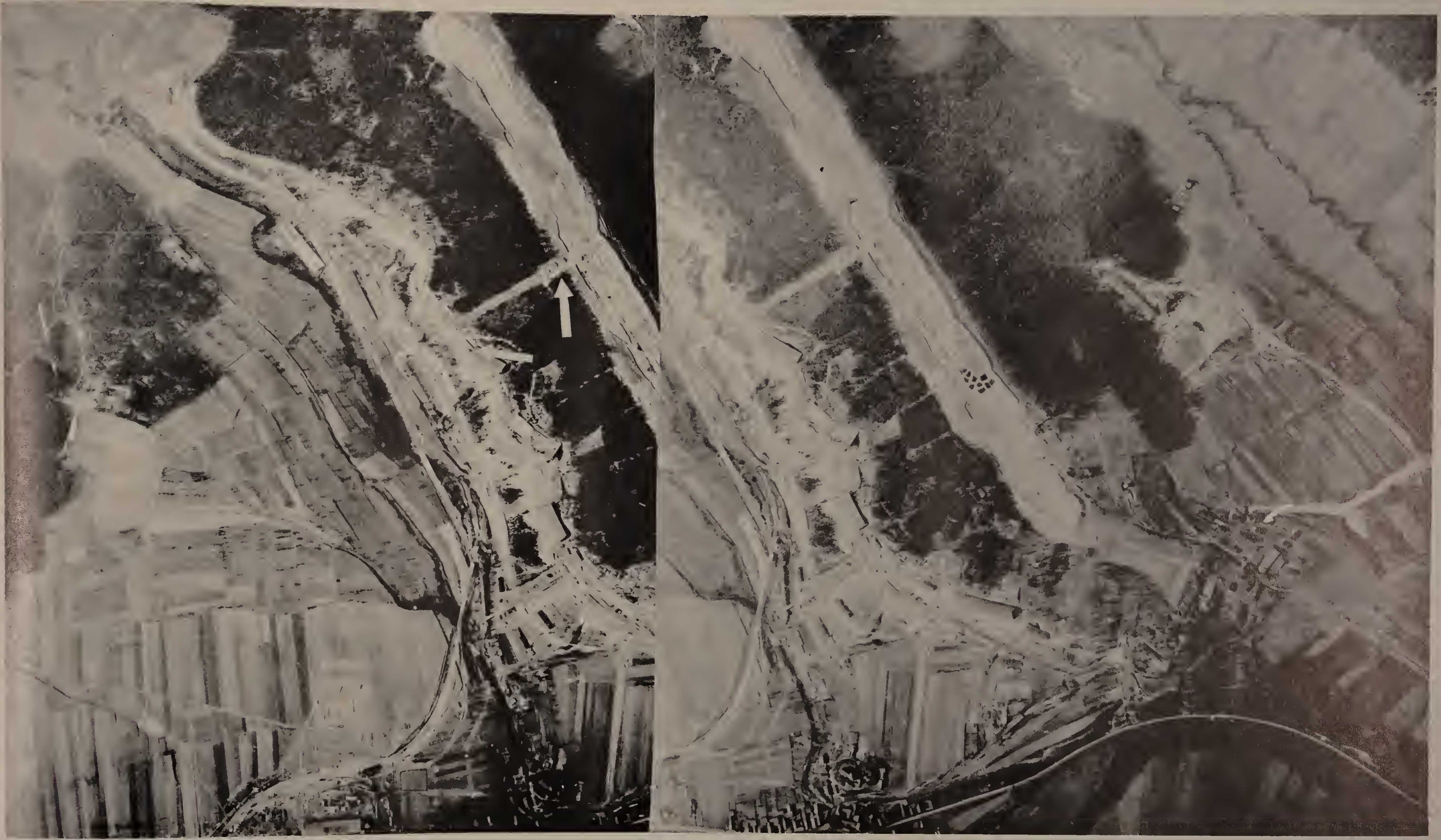


FIGURE 118. Stereogram of three ME 262 jet aircraft at the Reimahgbau underground aircraft factory at Grosseutersdorf near Kahla, Soviet Zone, Germany. This large underground factory was being built for the complete assembly underground of 1,000 fighter aircraft per month. There were 45 tunnel entrances and of a planned floor space of 2,726,000 square feet approximately 1,435,000 square feet were available at the end of the war. Part of this was provided by two small sandstone mines. Four main assembly tunnels each 50 feet wide were under construction. Approximately eight miles of new tunnels were excavatd. All parts were to have been made here with the exception of instruments, jet engines, and landing gear. The construction of the factory was not completed and no aircraft were assembled from parts made here. However, 16 aircraft were assembled from parts made elsewhere.

Cover: Prints 3039–3040 of Sortie 106G/4918, dated 19 March 1945.

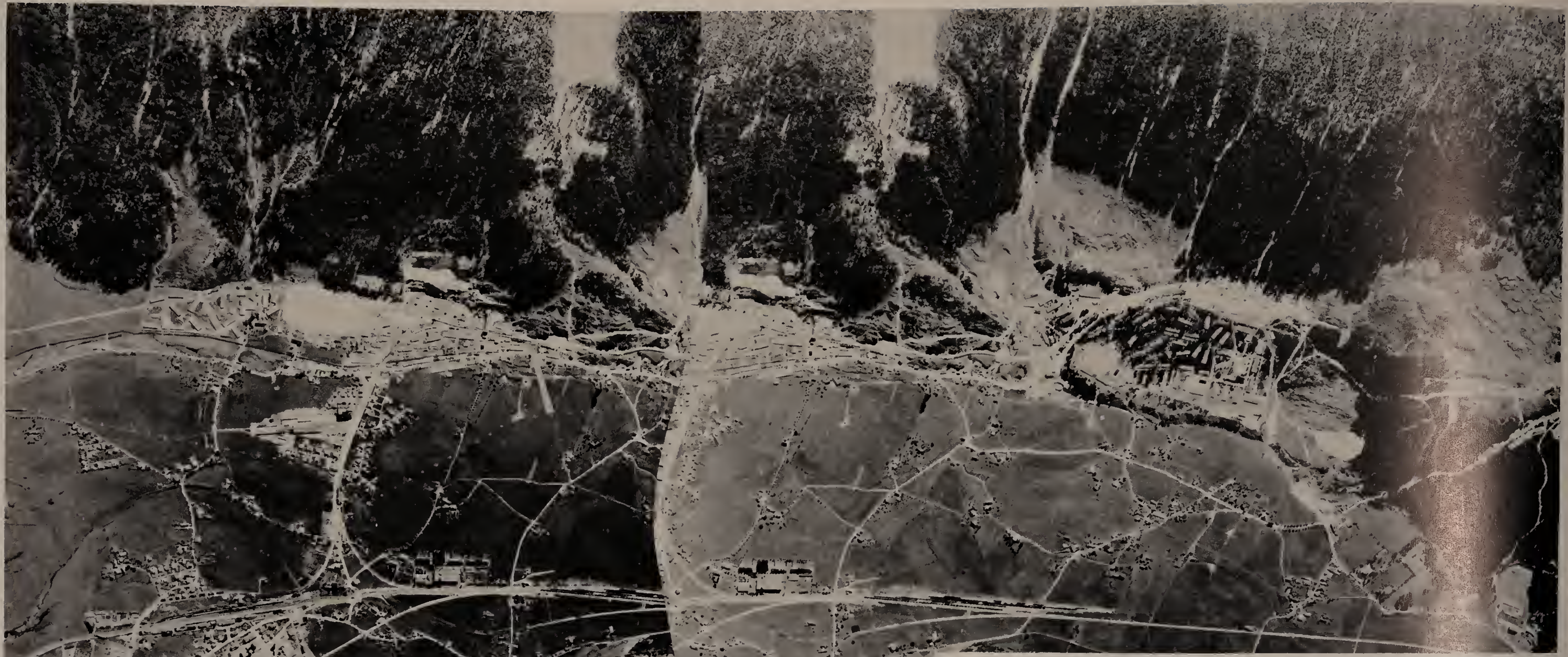


FIGURE 119. Stereogram of oil loading racks and tank cars at an underground oil refinery in new tunnels excavated in the face of a limestone quarry at Ebensee, U. S. Zone, Austria. These tunnels were excavated for a V–2 rocket factory and later modified for the refinery. For this reason they were not entirely satisfactory. However, the refinery did get into production and was kept in production after the war, producing a total of 250 tons of petroleum products per day, consisting of gasoline, diesel oil, and fuel oil. A plan of the above ground features at this site and an adjoining site is shown in Fig. 121.

Cover: Prints 4014–4015 of Sortie 106G/5441, dated 25 April 1945.

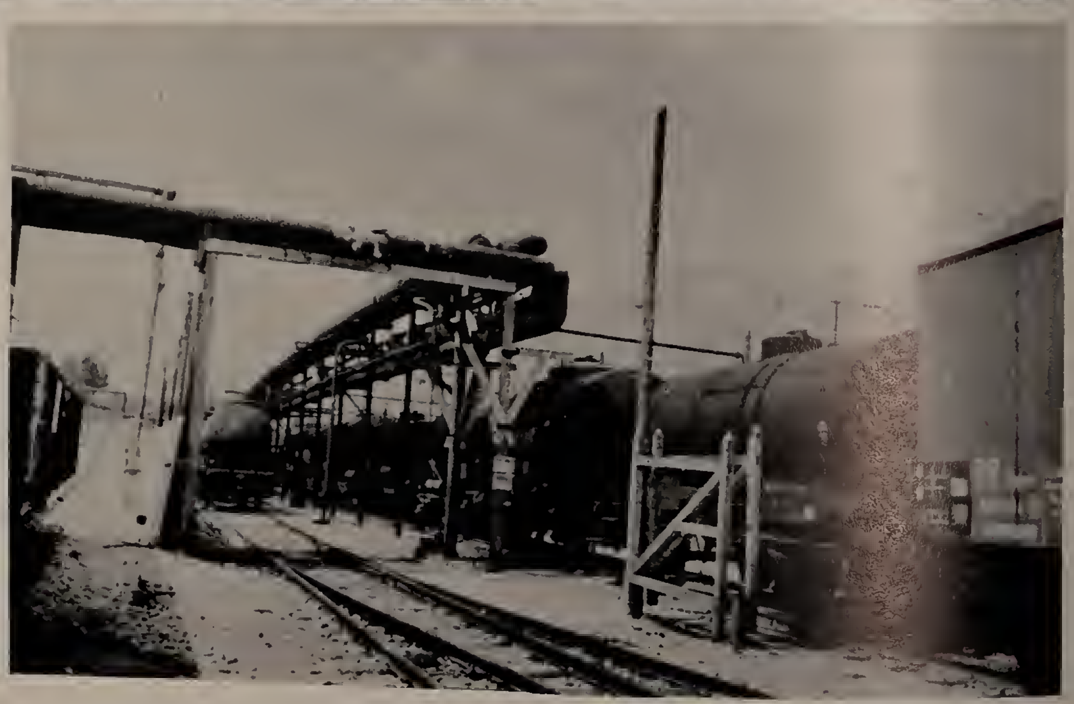


FIGURE 120. Loading racks and oil tank cars at the underground refinery at Ebensee, U. S. Zone, Austria, shown in Figure 119.

A Group of tunnels in quarry.

X–X′ Line of cross section through A.

B Group of tunnels behind concentration camp.

Y–Y′ Line of cross section through B.

1. Standard gauge railway spur.
2. Ten standard gauge sidings.
3. Six new standard gauge sidings.
4. Waste dump.
5. Maintenance shops for narrow gauge railway cars and engines.
6. Hydro-electric power station.
7. Hutted camp.
8. Concentration camp.
9. Warehouse and contractors huts.
10. Warehouse and open air storage of materials.
11. Sewage disposal plant.
12. Water well and pipe line.
13. Water well and pipe line.
14. Ditch.
15. Foundations for new buildings.
16. Plant for pre-fabrication of reinforced concrete arches used for lining tunnels.
17. Lumber yard.

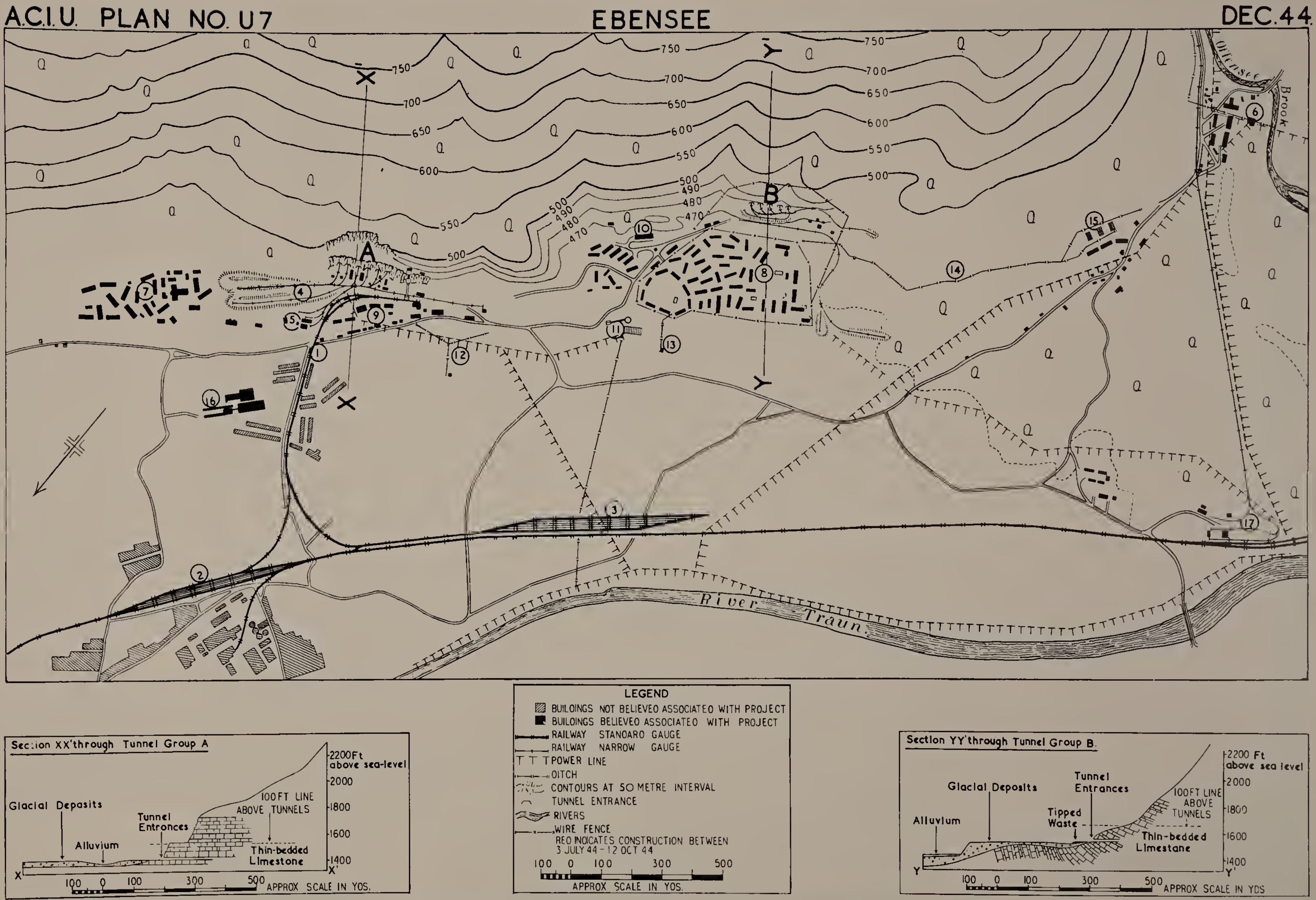


FIGURE 121. A plan of the above ground facilities and utilities at two underground installations at Ebensee, U. S. Zone, Austria. The original plan, of larger scale and in color, was prepared at the Allied Central Interpretation Unit, RAF Station Medmenham, England, during World War II and accompanied ACIU detailed P. I. Report U. 7 dated 18 December 1944. This plan, together with the geological cross sections, illustrates a technique evolved at ACIU for the presentation of detailed information on underground installations. All sources of intelligence were exploited and combined into the final product. The basic plan was drawn from enlarged rectified aerial photographs. The contours were taken from a German contour map and modified by photogrammetric means. The geological cross sections were constructed by means of a German geological map and the dip and strike of the geological formations checked on the aerial photographs. This plan was prepared from photographs taken before the oil loading rack shown in Figure 119 had been constructed. Other changes also can be noted. A ground check of the site confirmed the accuracy of the photo interpretation presented. Tunnel group A was for the underground refinery and tunnel group B was a Steyr Daimler Puch underground factory for the production of tank parts and aircraft engines. Production had started when the war ended. AF Neg. No. 276747.

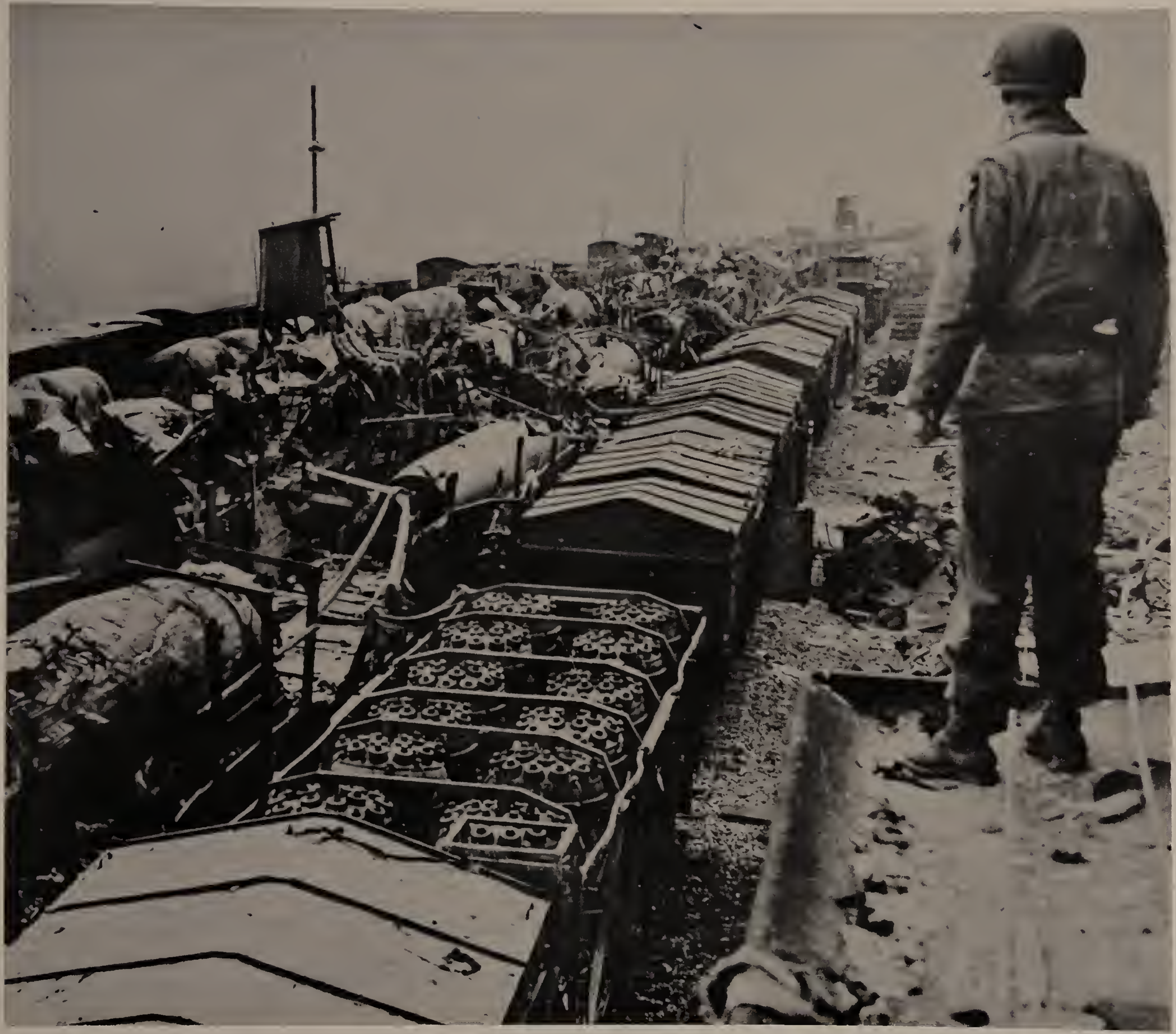


FIGURE 122. V–2 rockets on railway sidings at entrance to the underground V–2 factory at Niedersachswerfen near Nordhausen, Soviet Zone, Germany. The damage shown was not due to bombing. It was probably done by slave laborers. Train loads of rockets were made up here and shipped north to launching sites in Holland. Because the rockets were 46 feet 6 inches long and most of the German flat cars were only 26 to 33 feet long it was necessary to load two rockets on three cars. They were loaded nose to nose. Each three car unit was covered by tarpaulin supported by hoops or a framework as shown. Thus each three car unit at first glance appeared on aerial photographs as a single car and was in itself suspicious. Photographs of this underground factory caught one of these trains going around a bend and clearly showed that each of these long units was in fact three cars instead of one. Each car turned independently of the unit. Each of these trains was composed of ten three car units. A description of these trains and the suggestion that they were carrying V–2 rockets was published in a P. I. report on this underground factory. As a result, all photo interpreters at ACIU who studied daily railway activity were alerted to look for these peculiar trains. Within a week quite a number of them were spotted enroute from this factory to The Hague and elsewhere along the English Channel where the rockets were being fired at London. Further descriptions and illustrations of these trains were forwarded to fighter-bomber units on the Continent. Shortly afterwards aerial photographs of two of these trains that had been attacked confirmed the fact that these trains actually were hauling V–2 rockets. See Fig. 124. A stereogram of these three car units opposite the entrance to the factory is shown in Fig. 113 and even better photographs of them are shown in Fig. 123.

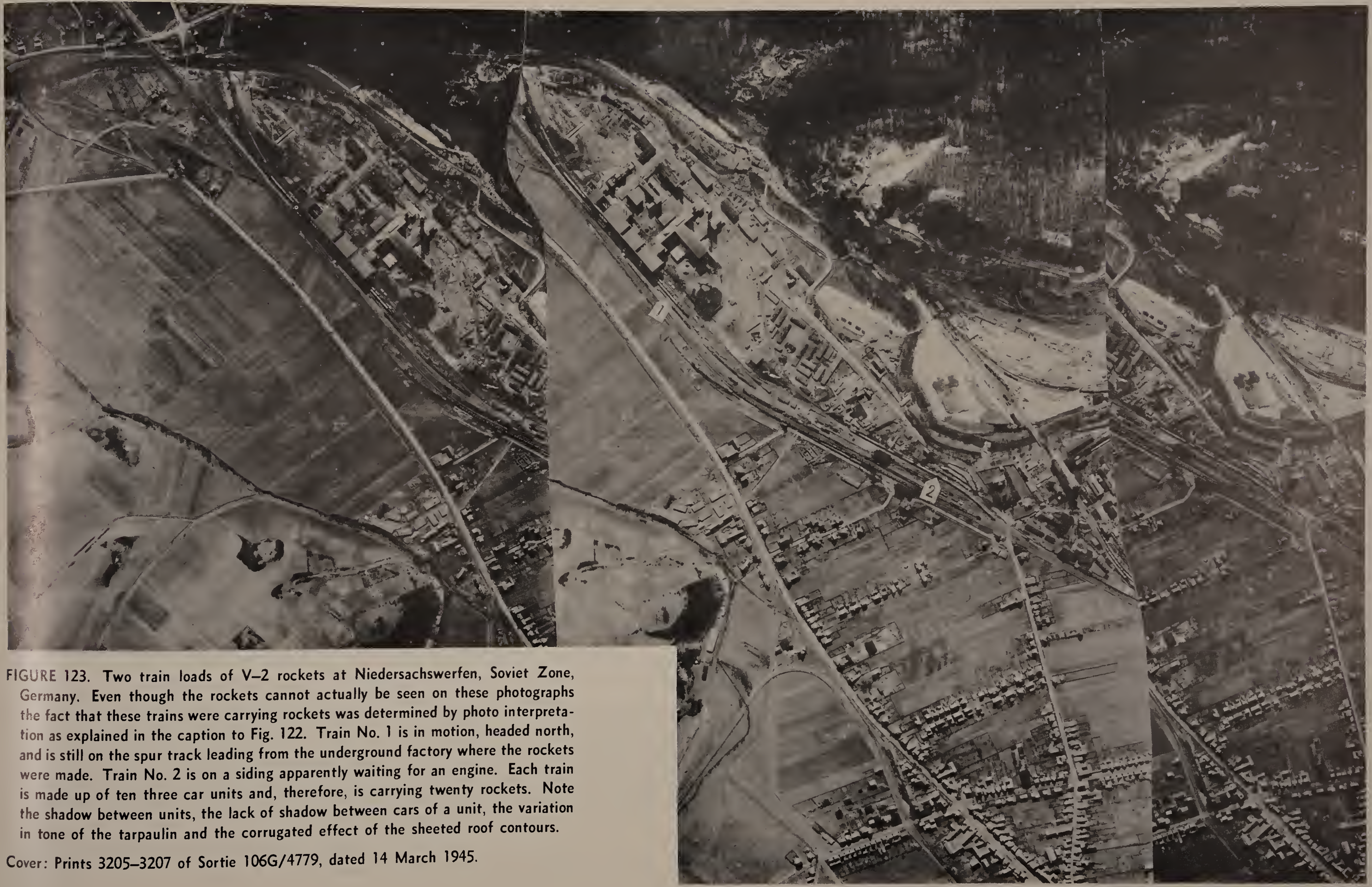


FIGURE 123. Two train loads of V–2 rockets at Niedersachswerfen, Soviet Zone, Germany. Even though the rockets cannot actually be seen on these photographs the fact that these trains were carrying rockets was determined by photo interpretation as explained in the caption to Fig. 122. Train No. 1 is in motion, headed north, and is still on the spur track leading from the underground factory where the rockets were made. Train No. 2 is on a siding apparently waiting for an engine. Each train is made up of ten three car units and, therefore, is carrying twenty rockets. Note the shadow between units, the lack of shadow between cars of a unit, the variation in tone of the tarpaulin and the corrugated effect of the sheeted roof contours.

Cover: Prints 3205–3207 of Sortie 106G/4779, dated 14 March 1945.

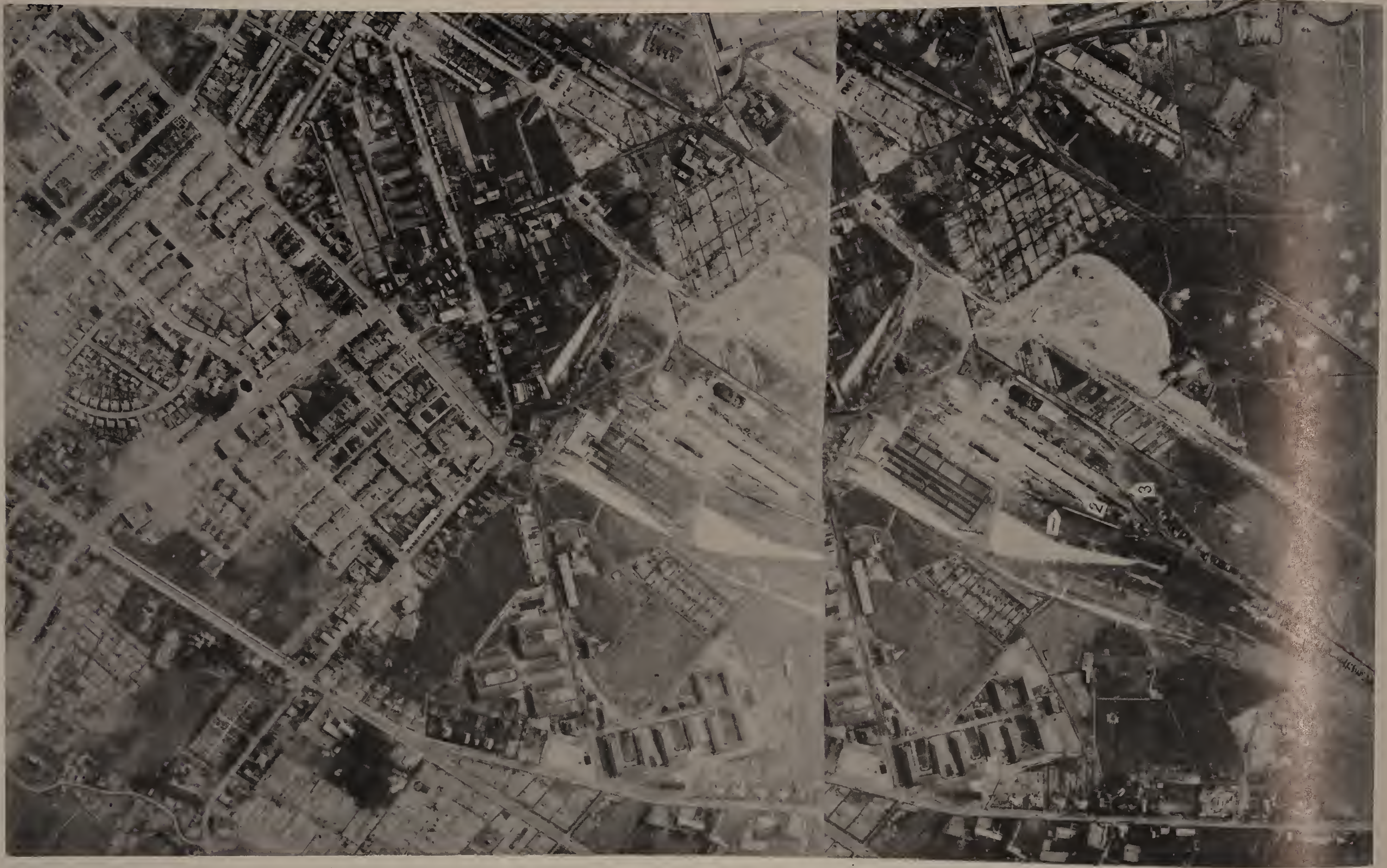


FIGURE 124. Stereogram of two train loads of V–2 rockets after an aerial attack at Wilhelmshaven, Germany. Note the seven three-car units on one track that are still covered by tarpaulin (1), the three adjacent units (2) that are partly unsheeted exposing three rockets, and the ten units on another track that were attacked (3). Apparently the tarpaulin either had been removed from these units or was blown off or burned during the attack. Note the rockets on the cars and on the ground. These photographs confirmed the fact that V–2 rockets were produced at the underground factory at Niedersachswerfen.

Cover: Prints 4022–4023 of Sortie 4/2256, dated 10 April 1945.

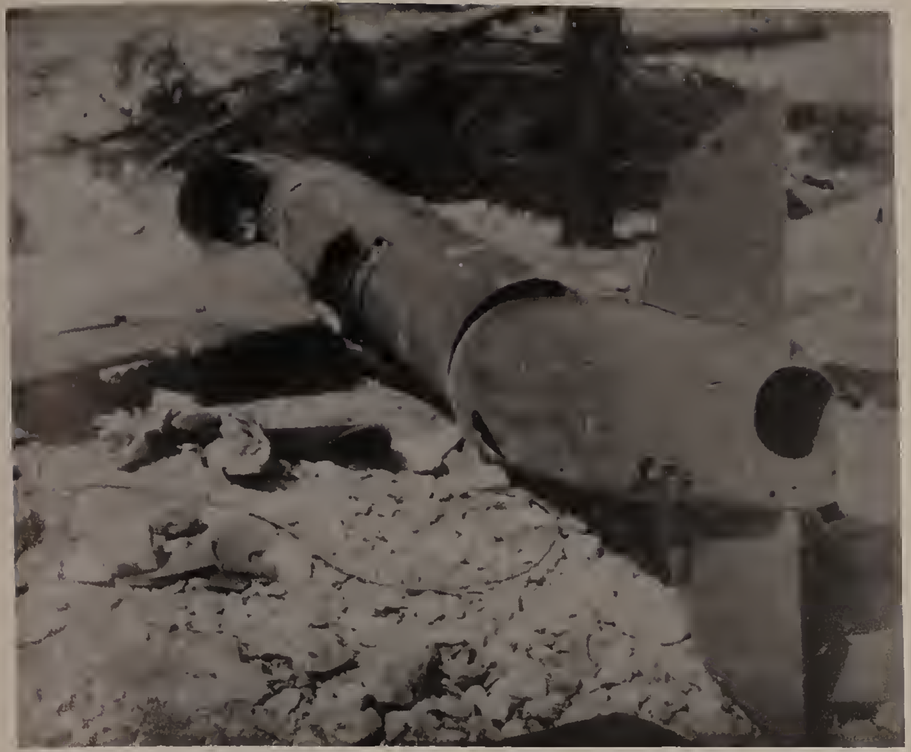


FIGURE 125. A ground to air guided missile, the HS 17 or Schmetterling, at the Henschel underground factory at Woffleben, Soviet Zone, Germany. Experimental production of these missiles had begun at this factory before the war ended. Photo by CIOS Team 163, June 1945.

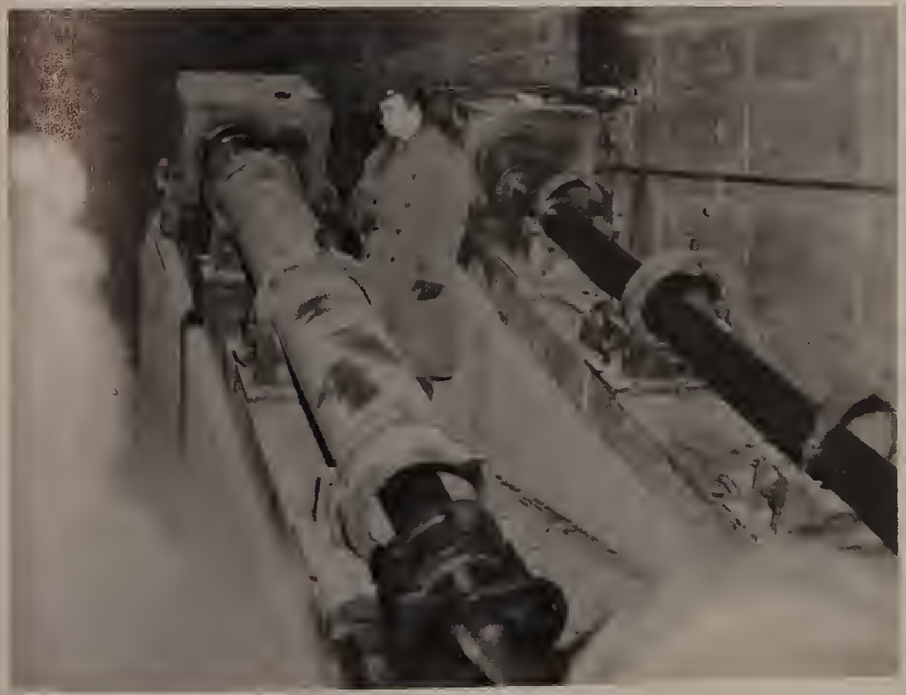


FIGURE 126. A flying bomb (V–1) launching tube in the Maschinenfabrik Augesburg-Nurnberg AG (MAN) underground factory at Weisenau, French Zone, Germany. Approximately 100 launching tubes were produced at this factory. Photo by A–2, USAFE, 1946.

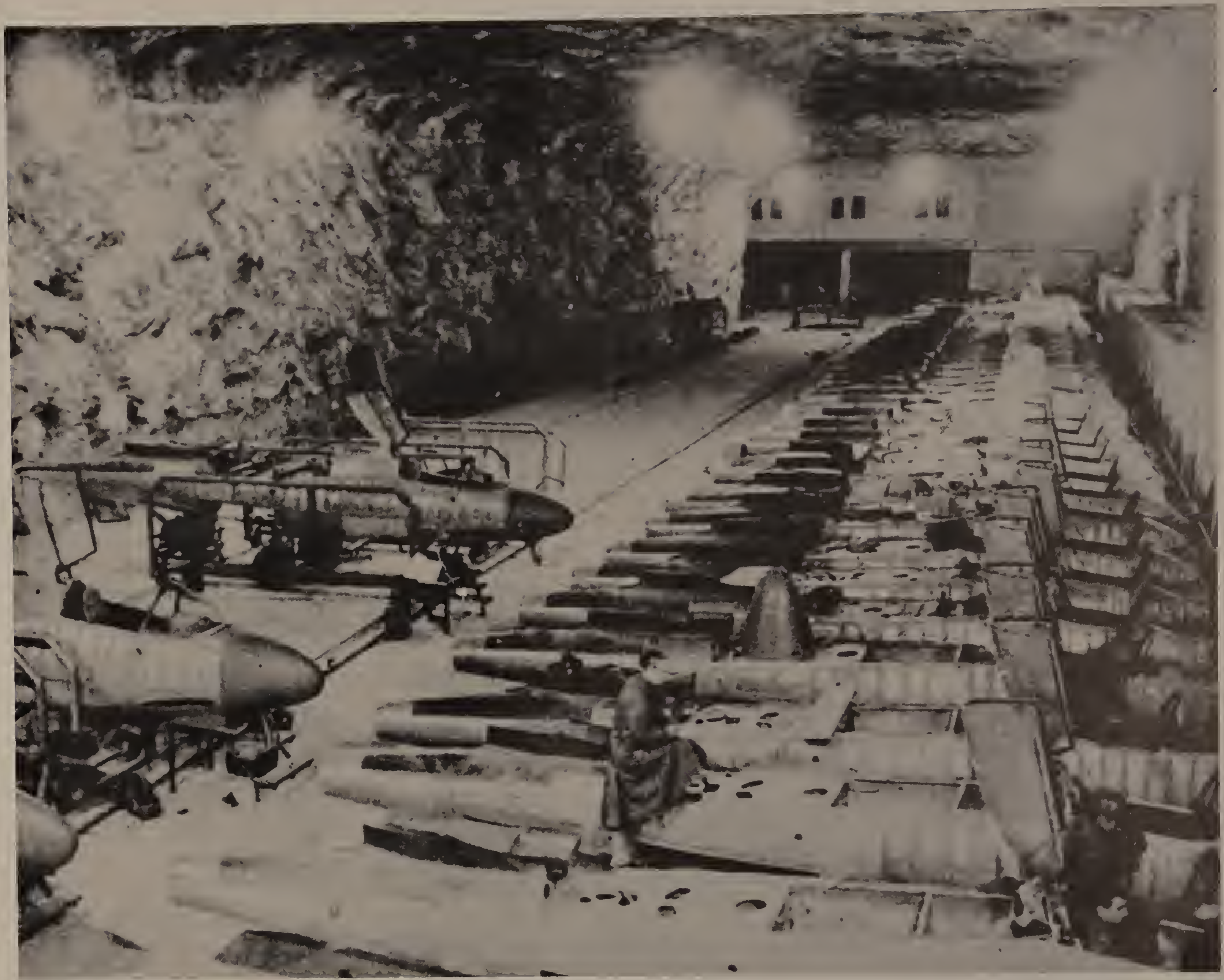


FIGURE 127. He 162 fuselage assembly line in the Junkers underground factory located 1,600 feet below the surface in a salt mine at Tarthun, Soviet Zone, Germany. The factory occupied approximately 350,000 square feet of floor space in the mine. Production started in June 1944 and approximately six fuselages were turned out per day, also parts for the Ju 88 and Fw 190. Manufacturing parts for the Ju 88 was the primary function of this factory. Approximately 1,500 workers were employed. Additional machine tools were being moved into the factory when the mine was captured. The factory was in excellent condition and all utilities and facilities operative. A standby power plant was available, service automatic. There were eight rooms, each 59 ft. wide by 35 ft. high and 160 to 263 ft. long. There were two shafts to the mine.

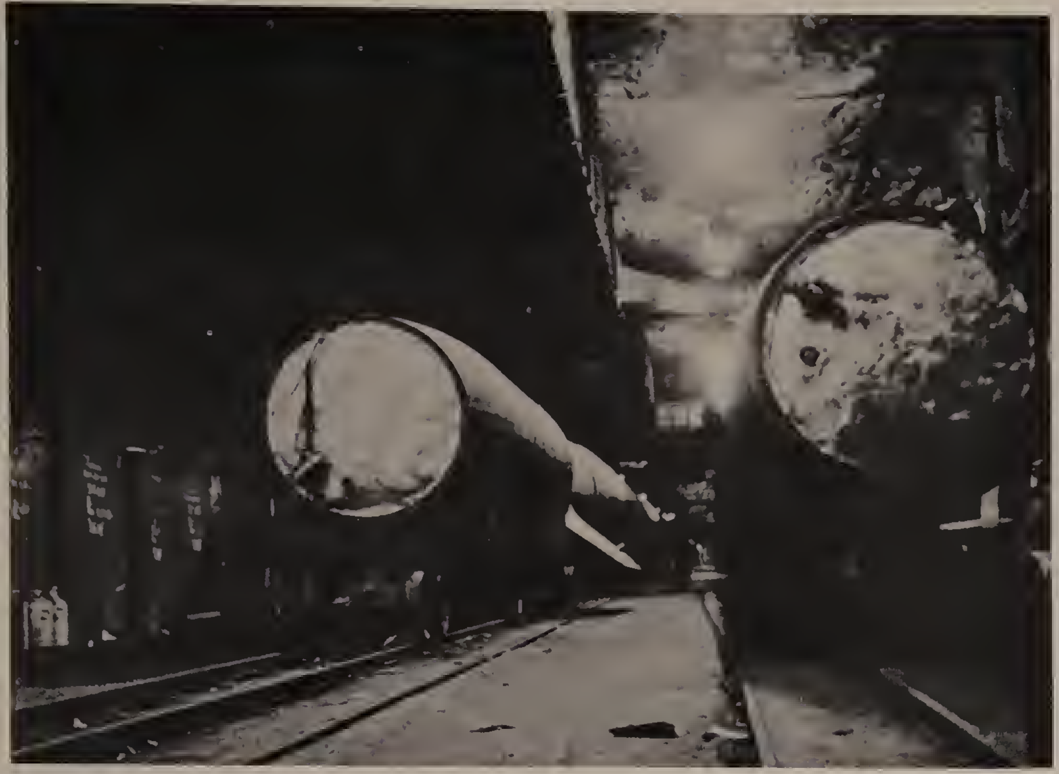


FIGURE 128. Assembled V–2 rockets, minus warhead, in the underground V–2 factory, Mittelwerk, at Niedersachswerfen, Soviet Zone, Germany. Approximately 10,000 V–2 rockets are reported to have been produced at this factory.

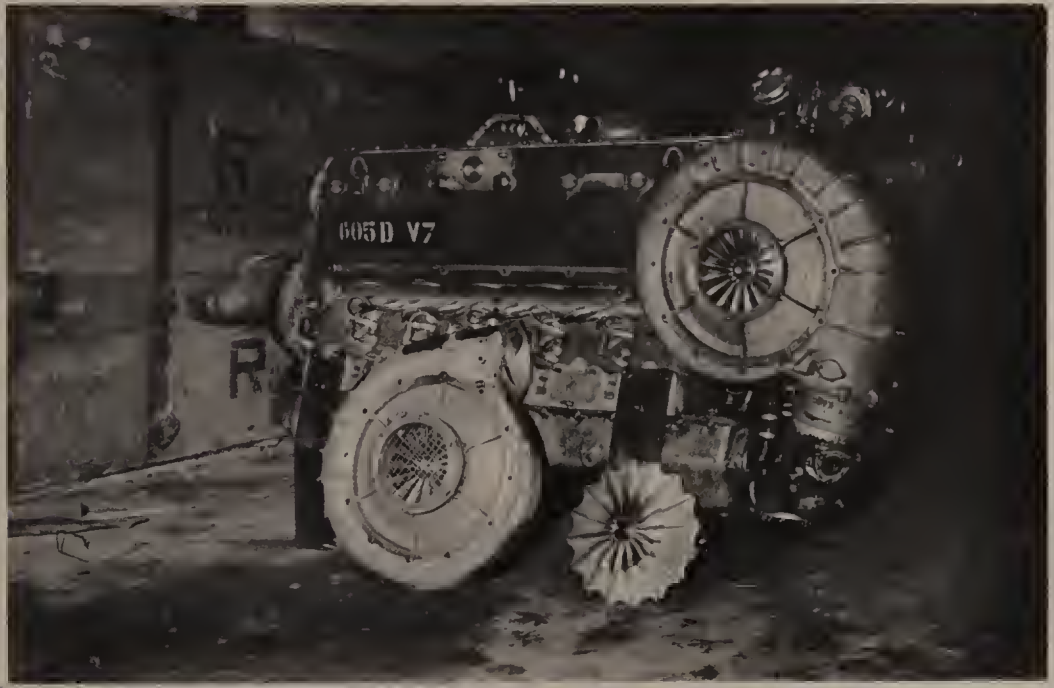


FIGURE 129. A D.B. 605 aircraft engine in the Daimler Benz underground factory, Goldfisch, at Neckarelz, U. S. Zone, Germany. Production reached a peak of 1000 D.B. 605's and 300 D.B. 603's per month. Photo by A–2, USAFE, 1946.

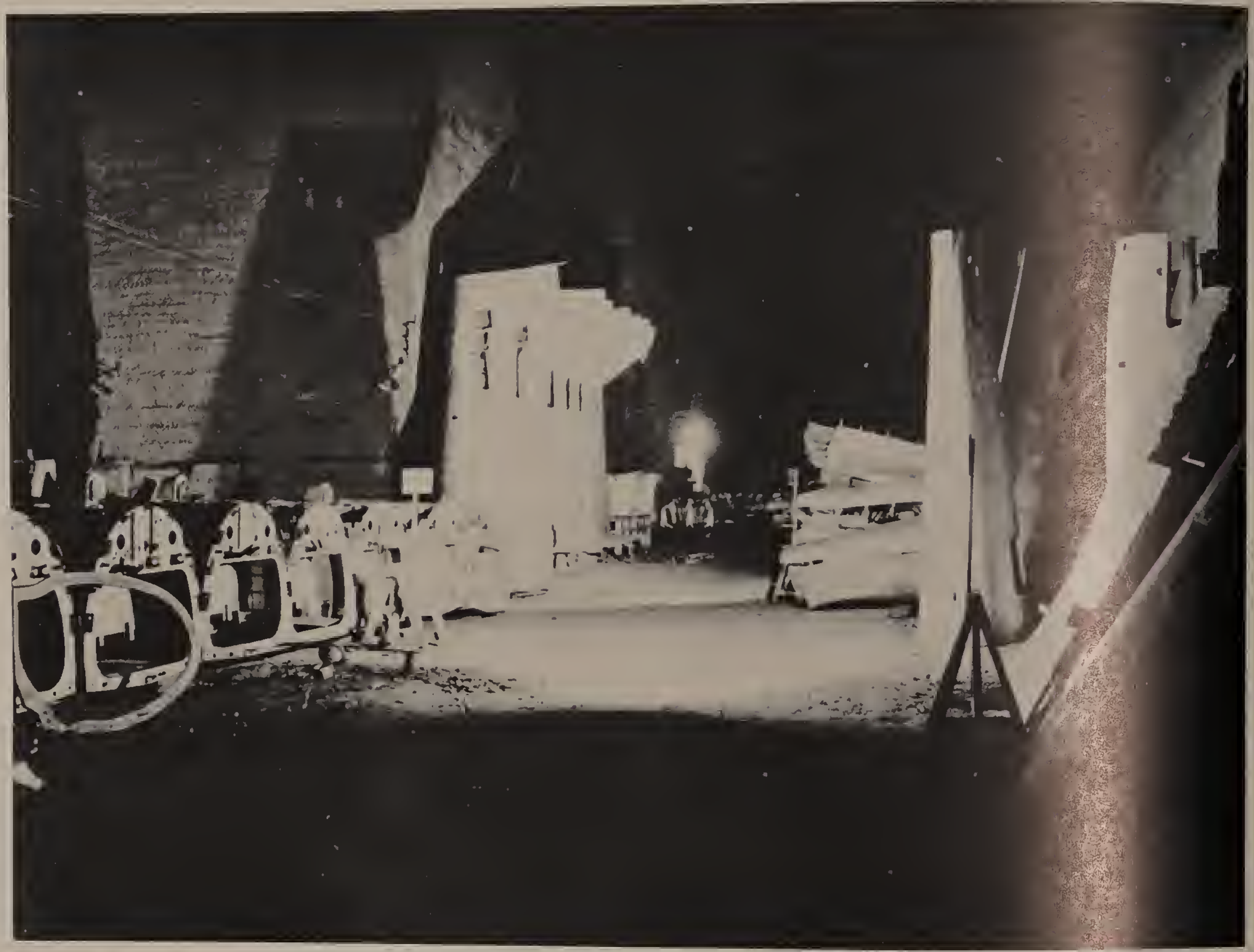


FIGURE 130. Aircraft fuselages, the Japanese Ki–84 or Army fighter Frank, in the Nakajima underground factory at Shiroyama, Japan. Planned production was three wing assemblies and three fuselages per day. Production had just started when the war ended. Photo by the U. S. Strategic Bombing Survey.

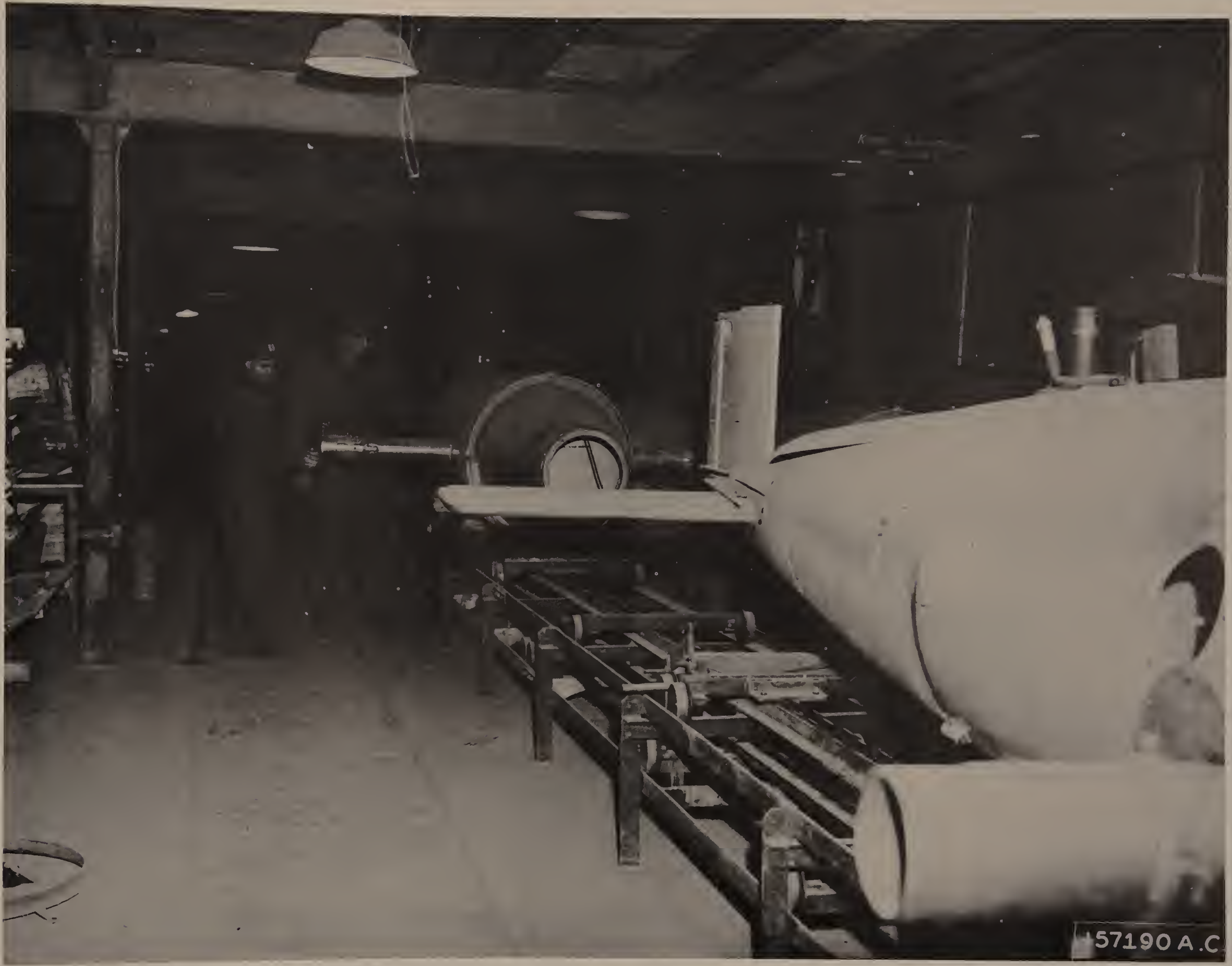


FIGURE 131. V–1 flying bomb assembly line in the underground V–1 and V–2 factory, Mittelwerk, at Niedersachswerfen, Soviet Zone, Germany. This factory is reported to have produced 7,100 flying bombs during World War II. Air Force photo No. 57190 A.C.

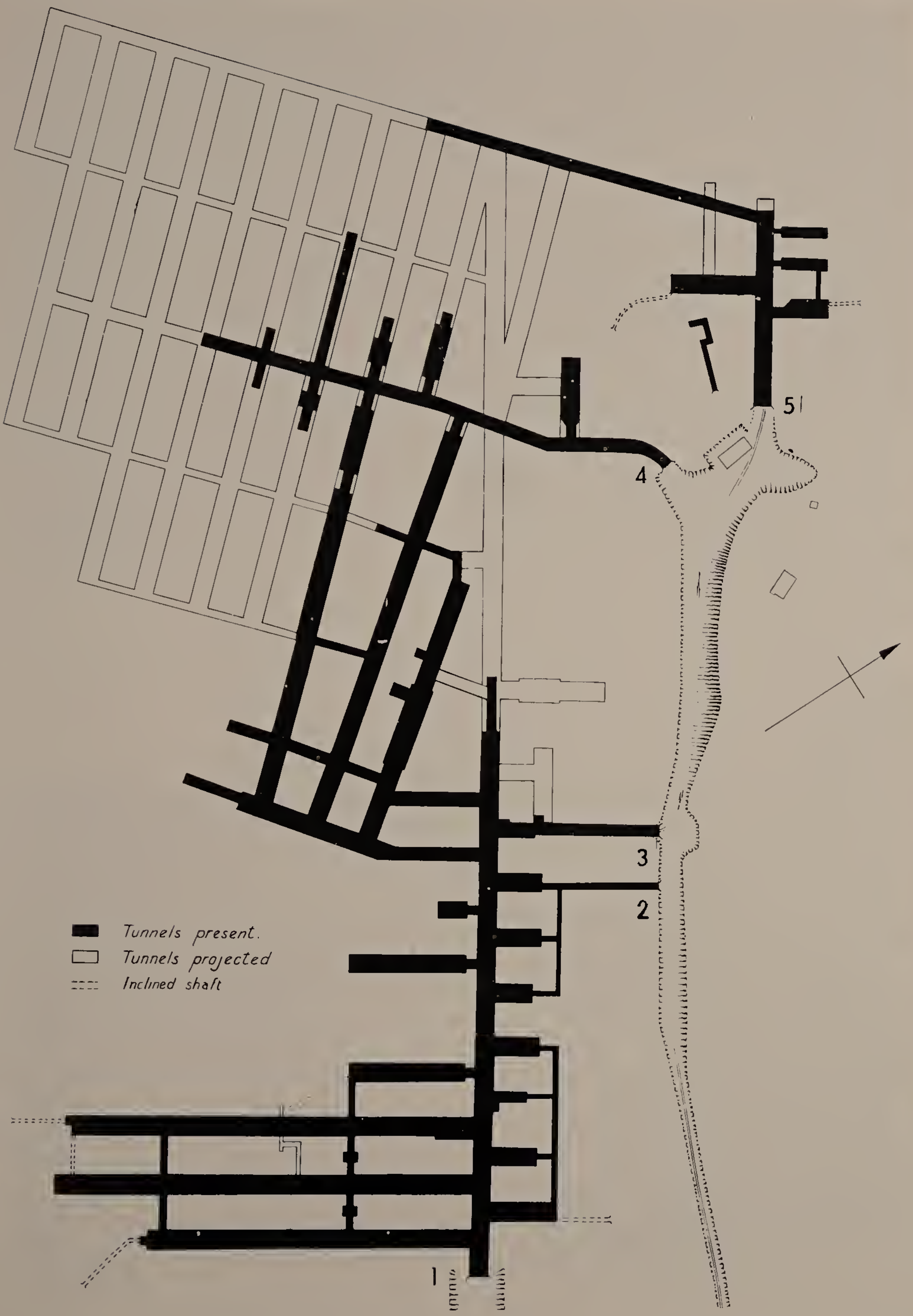


FIGURE 132. Tunnel plan of Project Tourmalin, a new tunnel grid for an underground factory in the Regenstein near Blankenburg, Soviet Zone, Germany. The plans show the status of the excavation at the end of World War II.

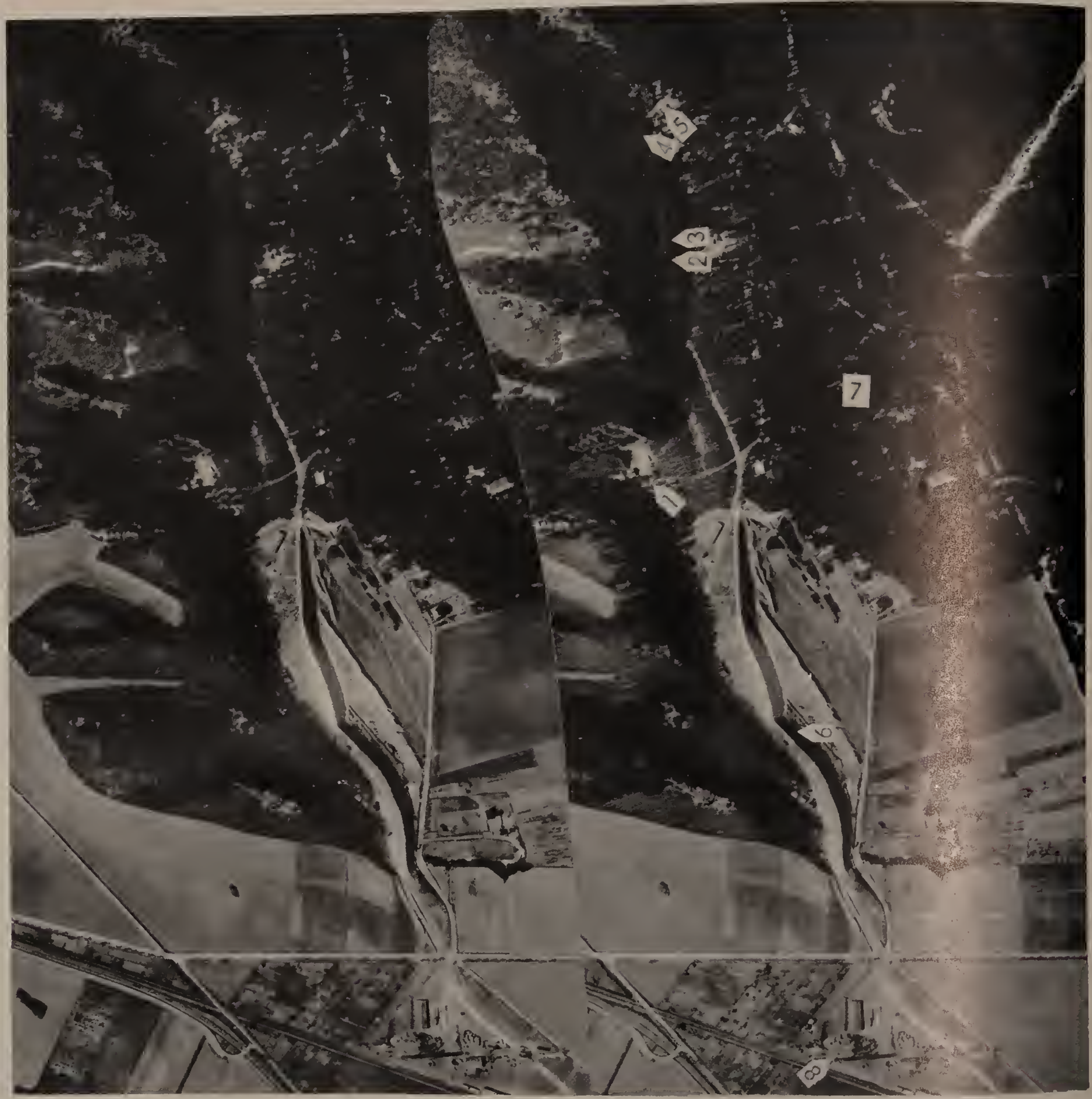


FIGURE 133. Stereogram of Project Tourmalin, near Blankenburg, Soviet Zone, Germany. Note the five tunnel entrances (1–5), the camouflaged spoil heap (6), the narrow gauge railway dump cars near (2), the labor camp and contractors buildings in the woods (7), the standard gauge railway siding (8), and the road and narrow gauge railway track leading from the siding to the project. A village type transformer substation and a small boiler house are located just outside Entrance No. 1. The main tunnels were 26 feet wide and of a total of 720,600 square feet of floor space planned approximately 190,900 square feet were excavated. The inclined shafts shown in Figure 132 were for ventilation.

Cover: Prints 4249–4250 of Sortie 106G/5056, dated 23 March 1945.

LEGEND

1–8. Tunnel entrances. Note loading ramps at entrances 4–6 and top of aerial tramway at concrete pump house between entrances 6 and 7.
9. Spoil or waste dump. Note spoil opposite and near all tunnel entrances and along narrow gauge railway track connecting them.
10. 90 cm gauge railway switchback and repair station.
11. 60 cm gauge railway.
12. Transshipment station.
13. Standard gauge railway spur.
14. Aerial tramway.
15. Contractors buildings.
16. Labor camp.
17. Camouflaged building.
18. Narrow gauge dump cars.
19. Water wells under construction and water pipe.
20. Power line under construction, indicated by row of pylons on ground.
21. Village of Happurg.

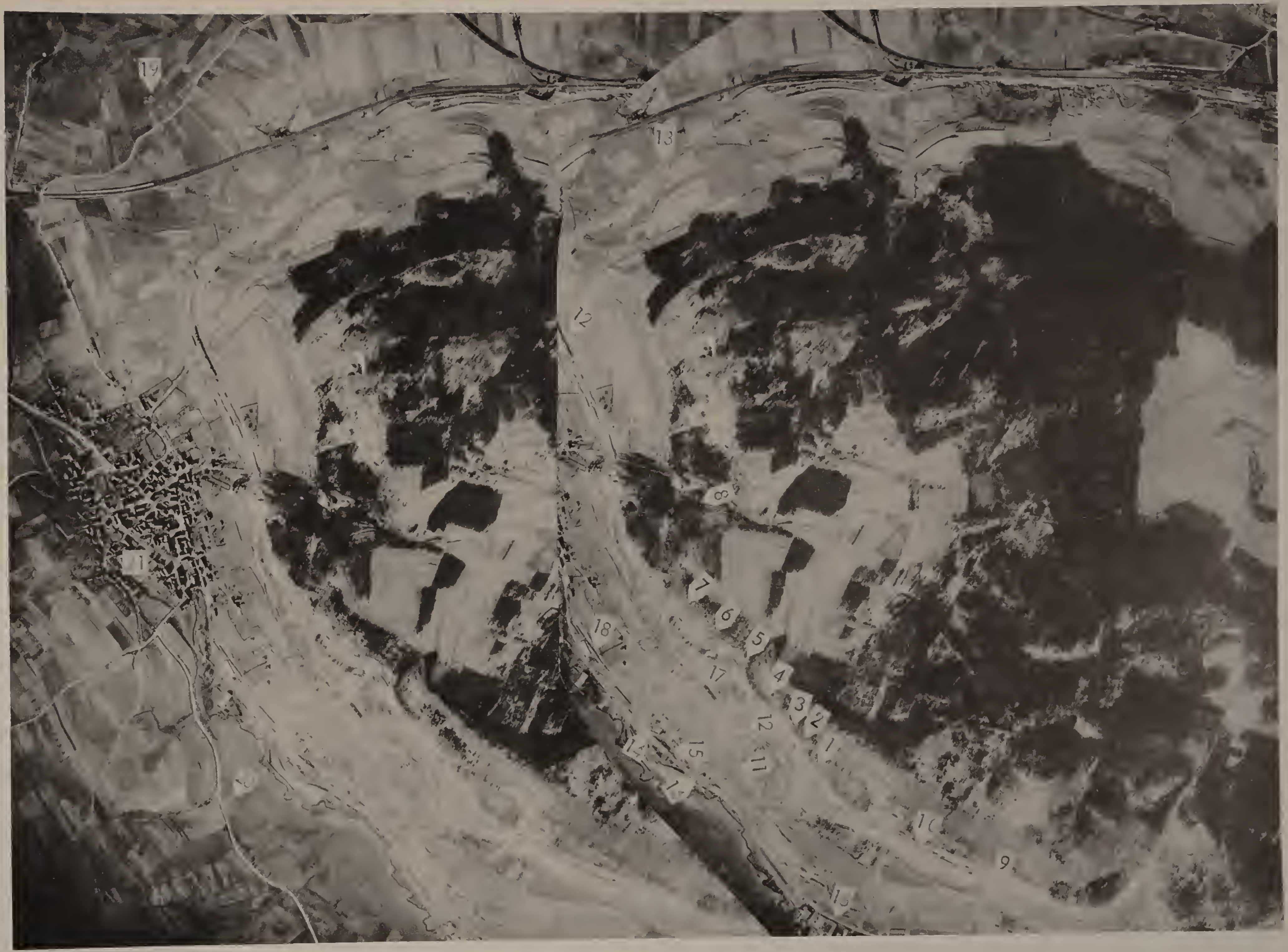


FIGURE 134. Project Dogger, a new network of tunnels under construction in 1945 in a hill at Happurg, 15 miles East of Nurnberg, U. S. Zone, Germany. Total underground floor space planned: 1,936,900 sq. ft.; excavated: 172,160 sq. ft.; lined with concrete: 64,560 sq. ft. The tunnels are 12 to 22 feet wide and 10 to 30 feet high. There are eight entrances. This project was planned for a BMW aircraft engine factory but later was allocated jointly to MAN, Telefunken, and Osram. No production was ever attained. This was a poor site for an underground factory because the only bed of rock here that was thick enough and strong enough lay high up on the side of the hill and was underlain by a thick bed of clay. Thus access was extremely difficult. Earth slides along the side of the hill were common.

Cover: Prints 3118–3119 of Sortie 106G/4846, dated 16 March 1945.

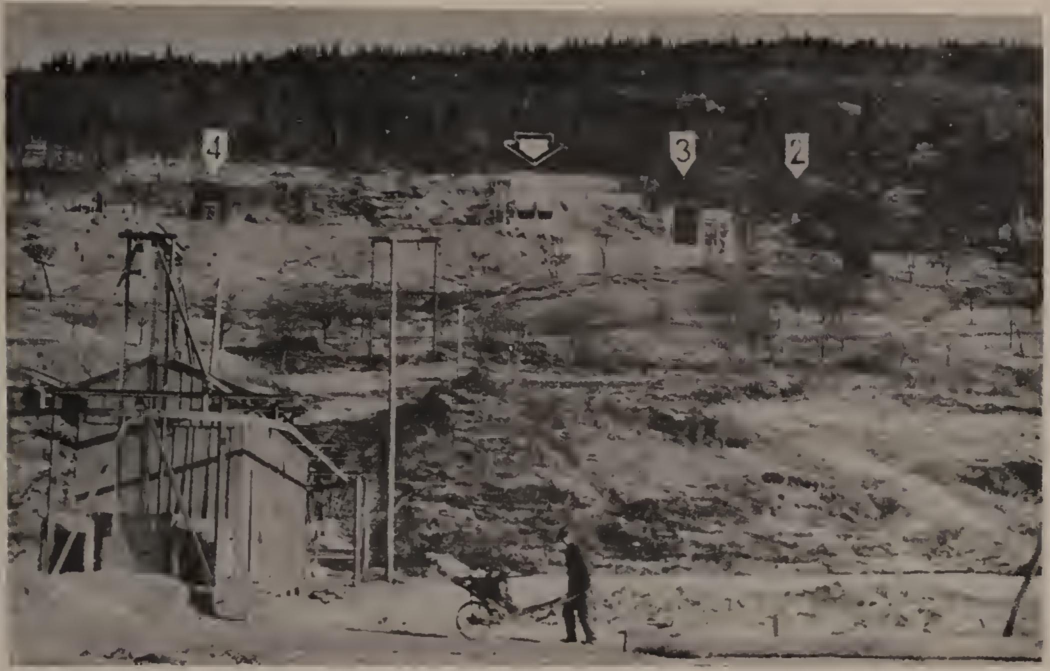


FIGURE 135. Lower end of the aerial tramway that terminated between tunnels 3 and 4 at Project Dogger. This aerial tramway was used to haul concrete up to the tunnels and to a reinforced concrete structure being built to house the machinery for operating an inclined cable railway, indicated by an arrow in the photograph. Tunnel entrances are indicated by the same numers used in Fig. 134. Photos by A–2, USAFE, 1946. AF Neg. No. 276573.

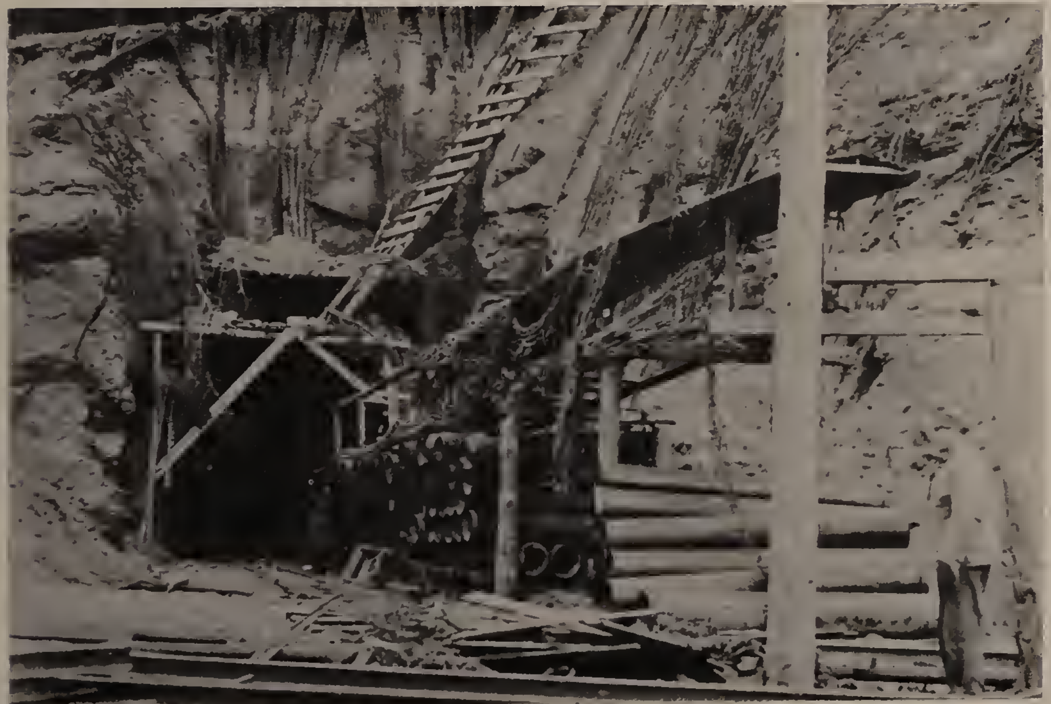


FIGURE 136. Tunnel entrance at Project Dogger. The pipe stacked beneath the loading ramp was used for the removal of dust and fumes during the excavation of the tunnels.
Photo by A–2, USAFE, 1946. AF Neg. No. 276572.

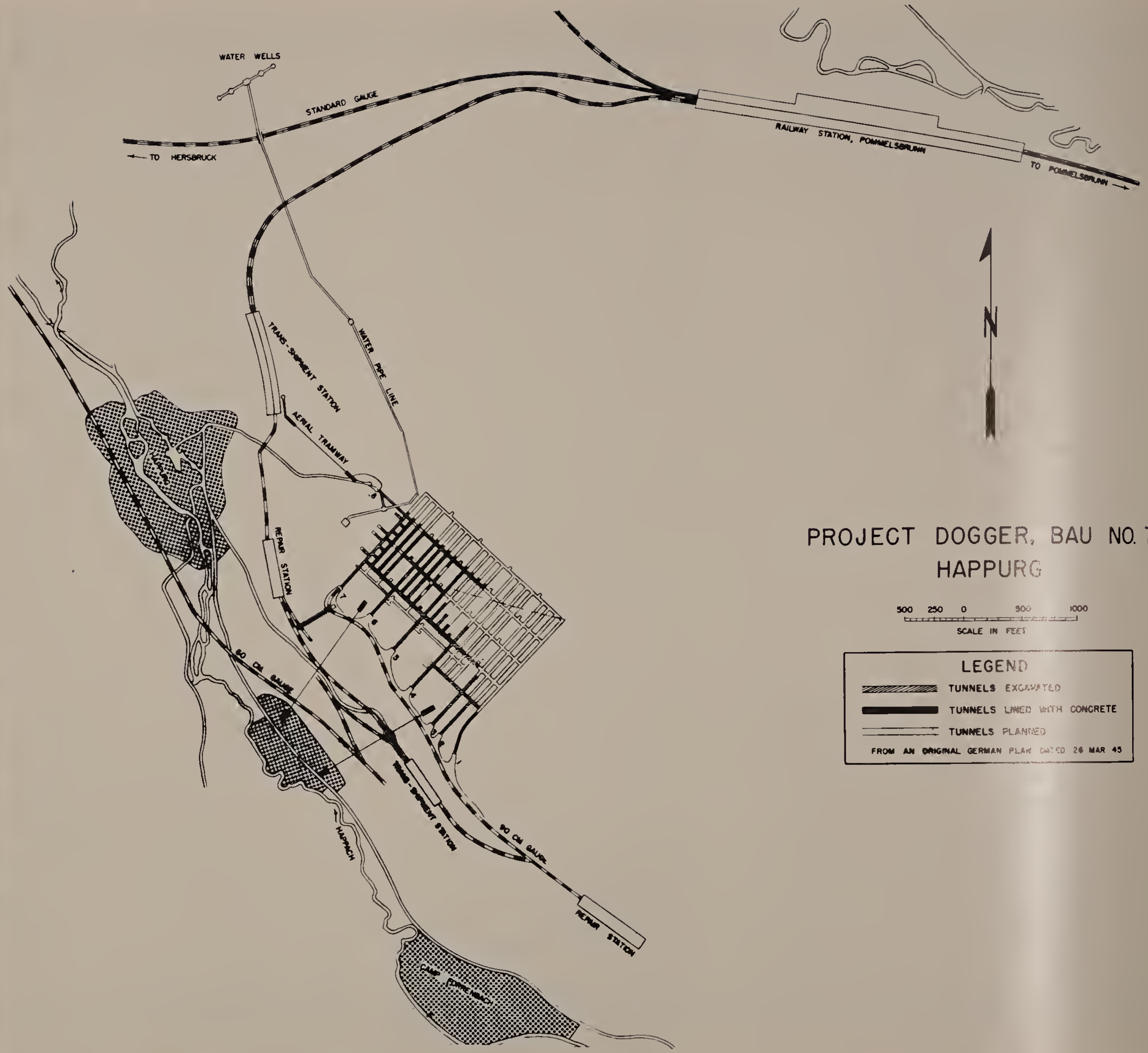


FIGURE 137. Plan of Project Dogger, near Happurg, U. S. Zone, Germany. The tunnels are shown as they were at the end of the war. The exterior facilities shown indicate the German plan on 26 March 1945. Compare this illustration with Fig. 134. By the end of the war the water pipe line and the aerial tramway opposite tunnel 8 had not been completed and the site selected for the inclined railway remained near tunnel 3. The narrow gauge railway system and the standard gauge spur were completed and can be seen in Fig. 134. The two aerial tramways on the south side also were completed but are extremely difficult to see on the small scale photograps shown in Fig. 134. The terminal buildings, however, can be seen. A photograph of tunnel 4 is shown in Fig. 27. The aerial tramway which terminates between tunnels 6 and 7 is shown in Fig. 40.

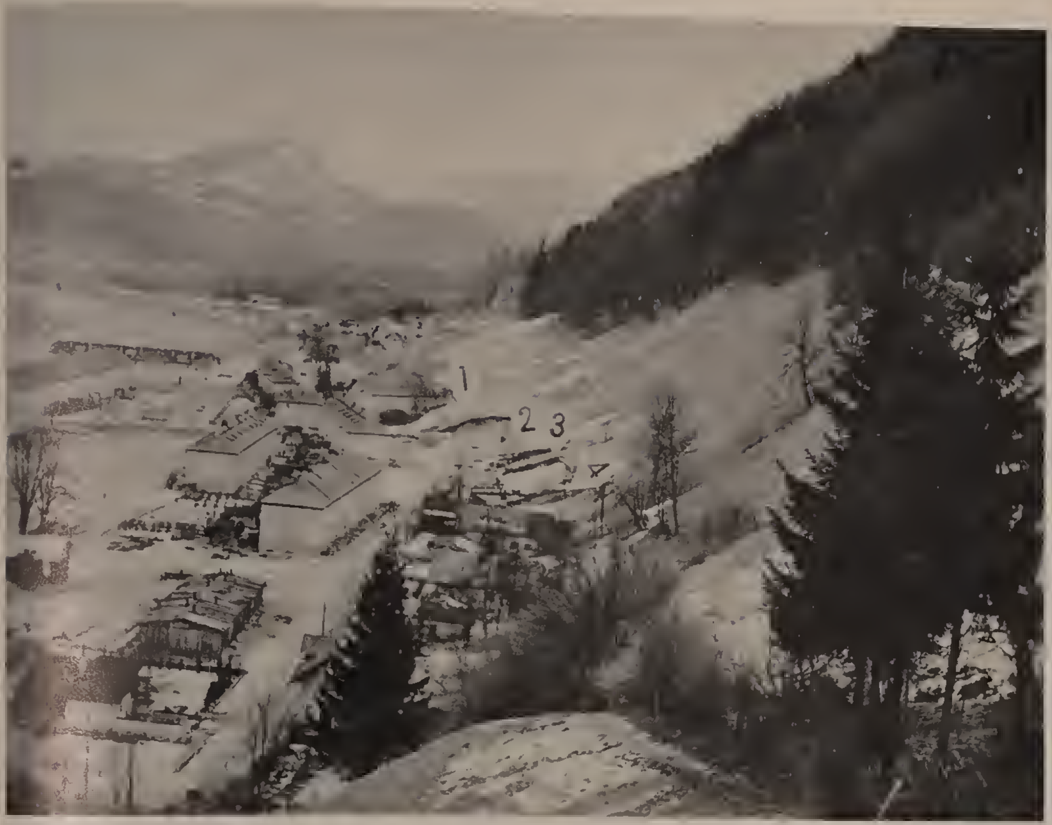


FIGURE 138. View looking south, of the four tunnels at the Eugen Grill Werke underground factory at Hallein, U. S. Zone, Austria. Photo by A–2, USAFE. January 1946.

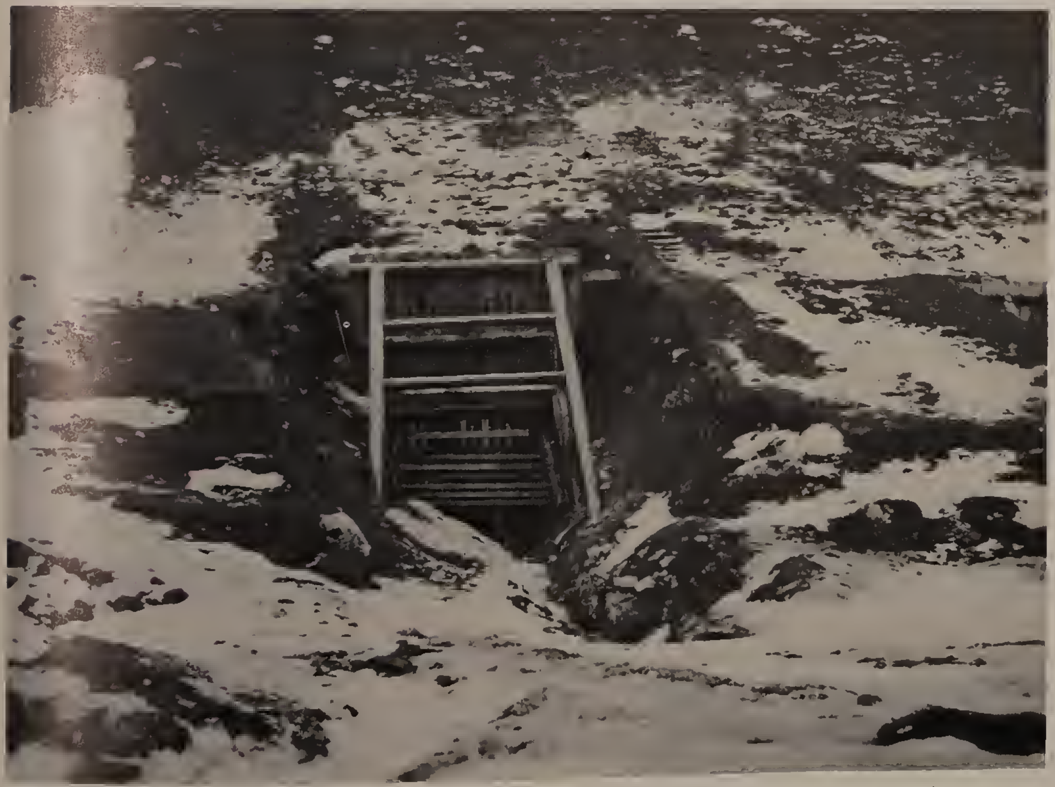


FIGURE 139. Entrance No. 2 at the Eugen Grill Werke underground factory shown in Figs. 138 and 140. Photo by A–2, USAFE, January 1946.

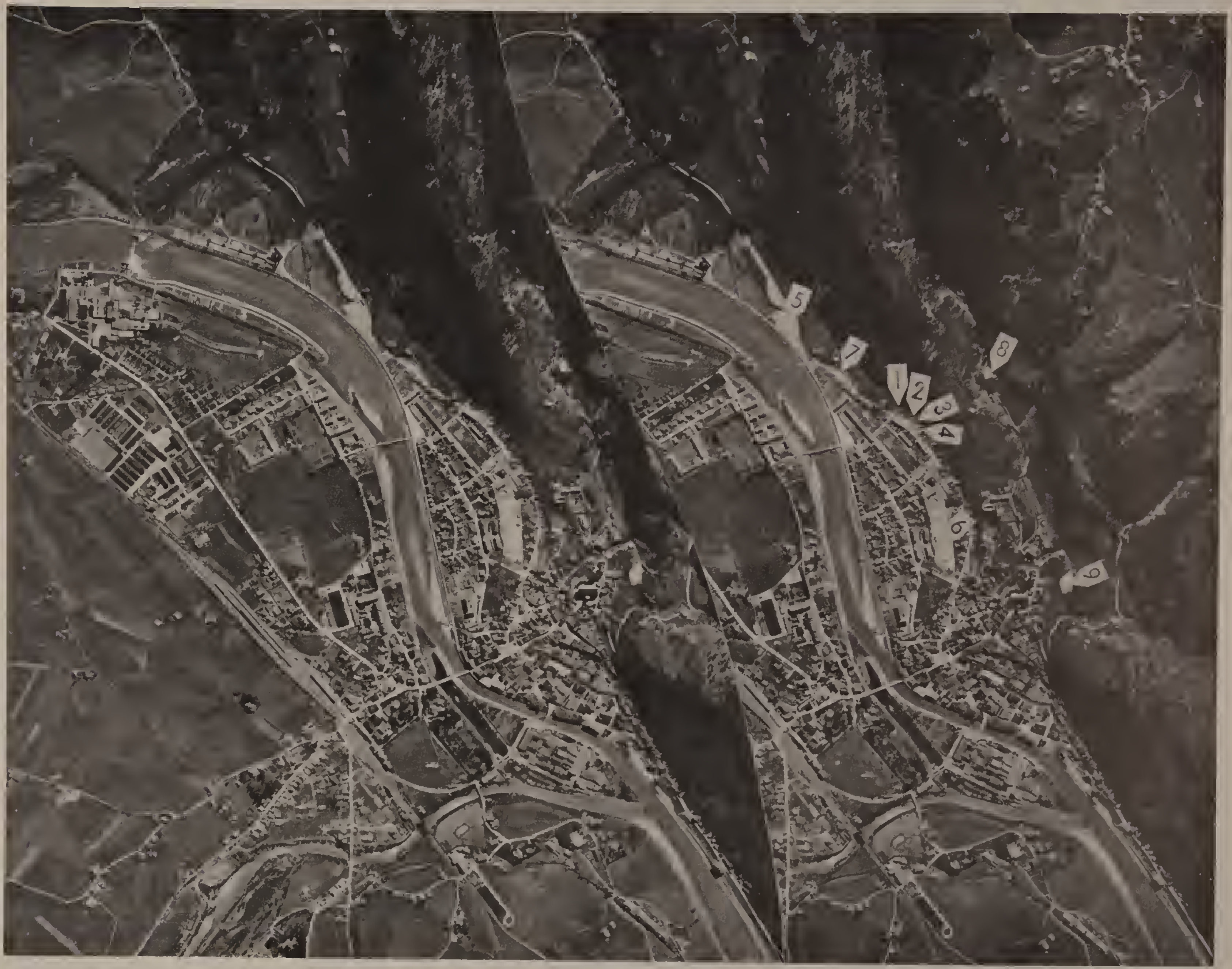


FIGURE 140. Stereogram of the Eugen Grill Werke underground factory at Hallein, U. S. Zone, Austria. Note the four tunnels (1–4) and the steam pipe leading from tunnel 3 to tunnel 4. Tunnel 3 housed a steam boiler and was not connected to the network of new tunnels which housed the factory. Tunnels 1, 2, and 4 were entrances to the factory. Note the large spoil heaps (5–6) and the open air storage of materials (7). This factory was in production for about three weeks before it was captured and it produced components for an automatic fuel control apparatus for aircraft (Kommando Geraet) as well as parts for Mauser and Steyr guns. About 620 workers were employed and 170 machine tools were in the factory at the end of the war. The total planned floor space was 91,432 square feet of which 88,232 square feet were excavated and 39,698 square feet were in production. The completed tunnels were lined with concrete. The spoil at (8) marks the site of a salt mine and that at (9) the excavation of new air raid tunnels.

Cover: Prints 3138–3139 of Sortie 106G/5272, dated 10 April 1945. Scale: 1/17,800.

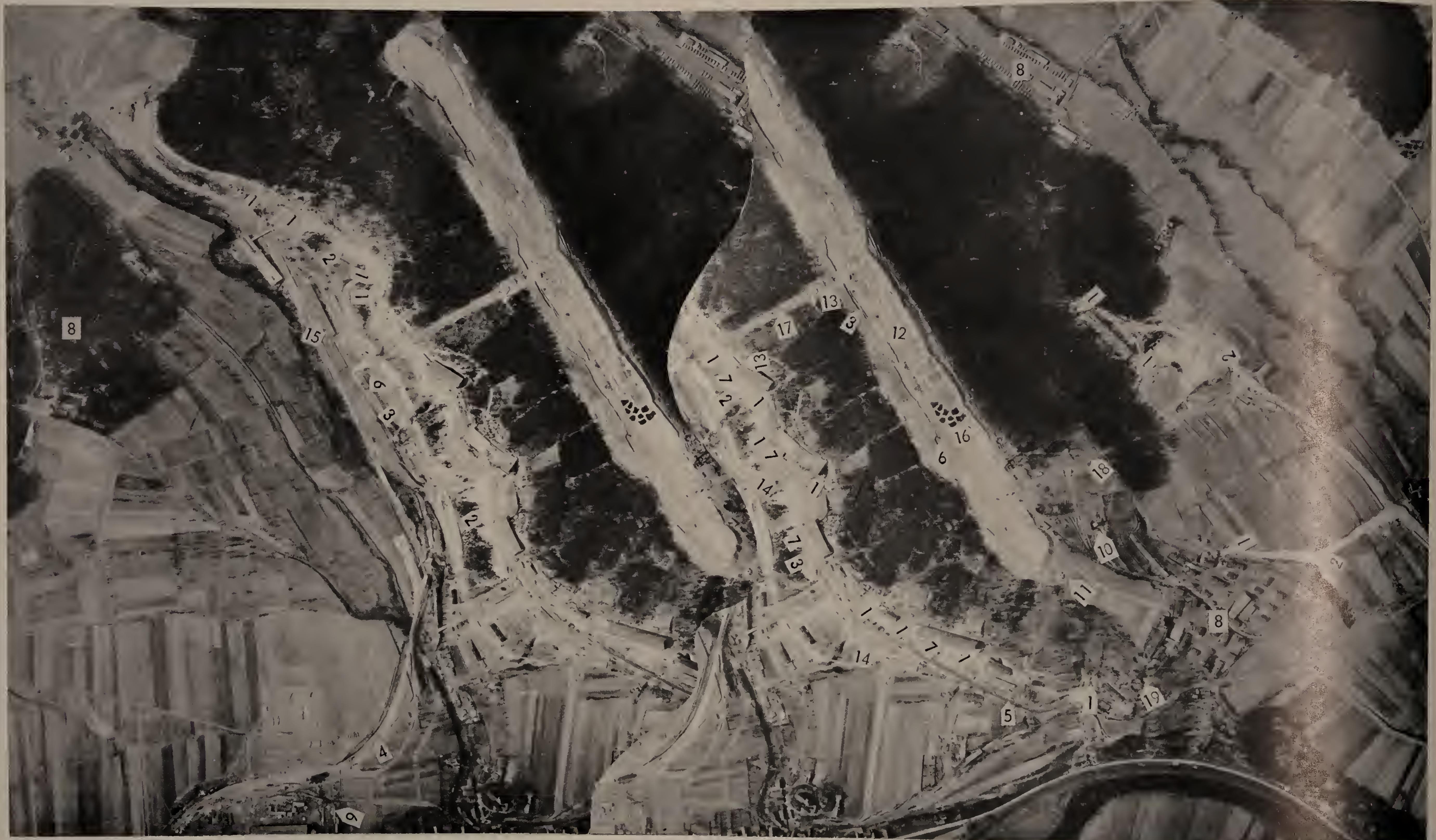


FIGURE 141. Stereogram of the Reimahgbau underground aircraft factory at Kahla, Soviet Zone, Germany. See also Figs. 75, 76, 118, 142, and 143. Note the following: tunnel entrances (1), spoil heaps (2), narrow gauge railway (3), standard gauge railway spur (4), new road (5), excavating equipment (6), temporary assembly buildings with thick concrete roofs (7), labor camps (8), open air storage (9), transformer station (10), water pipe line and buried storage tank (11), factory airfield (12), finished products, Me 262 jet fighter aircraft (13), camouflage nets on spoil heaps (14), camouflage paint on buildings (15), camouflage paint on runway (16), inclined cable railway for transport of aircraft to runway (17), inclined cable railway (18), areas of subsidence over old mine tunnels where overburden was thin (19).

Cover: Prints 3039–3040 of Sortie 106G/4918, dated 19 March 1945. Scale: 1/8,350.

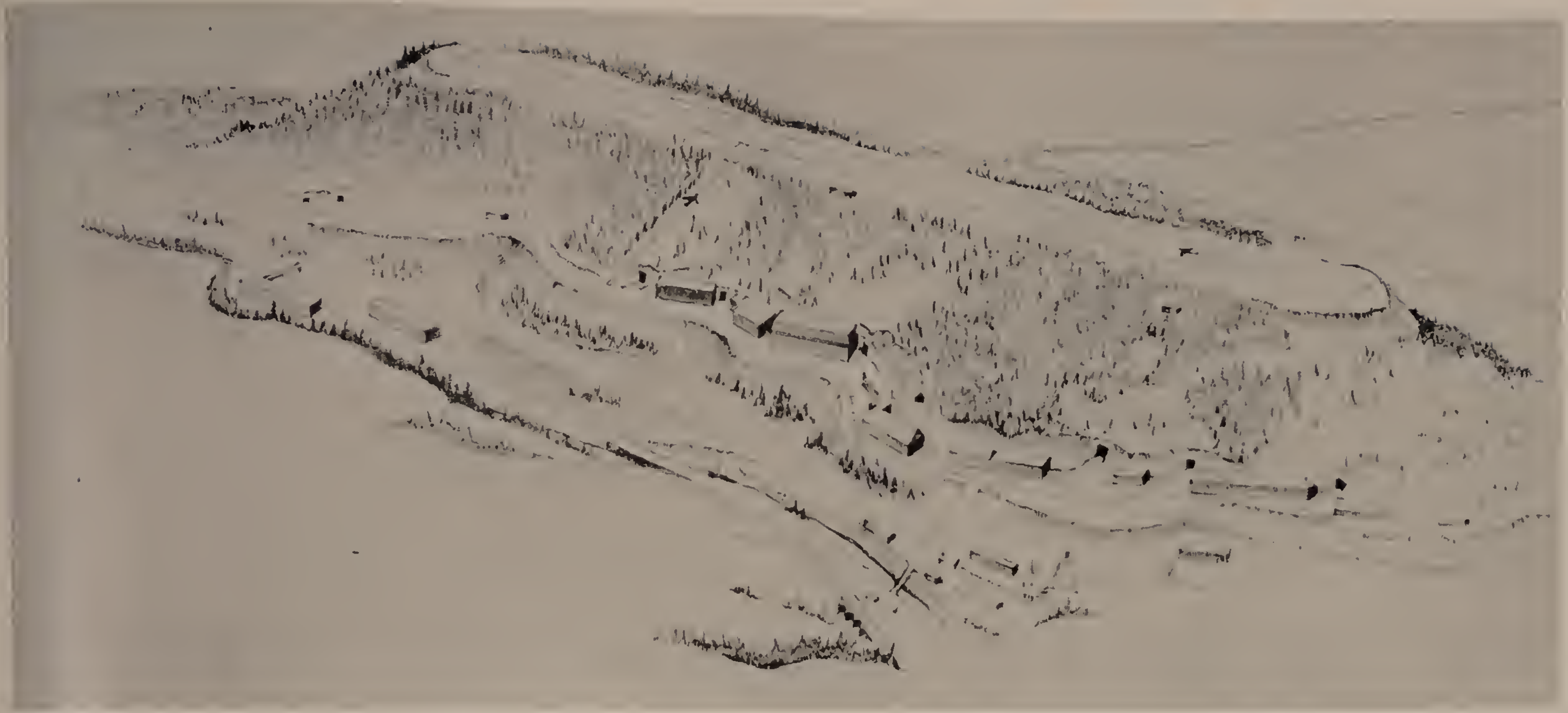
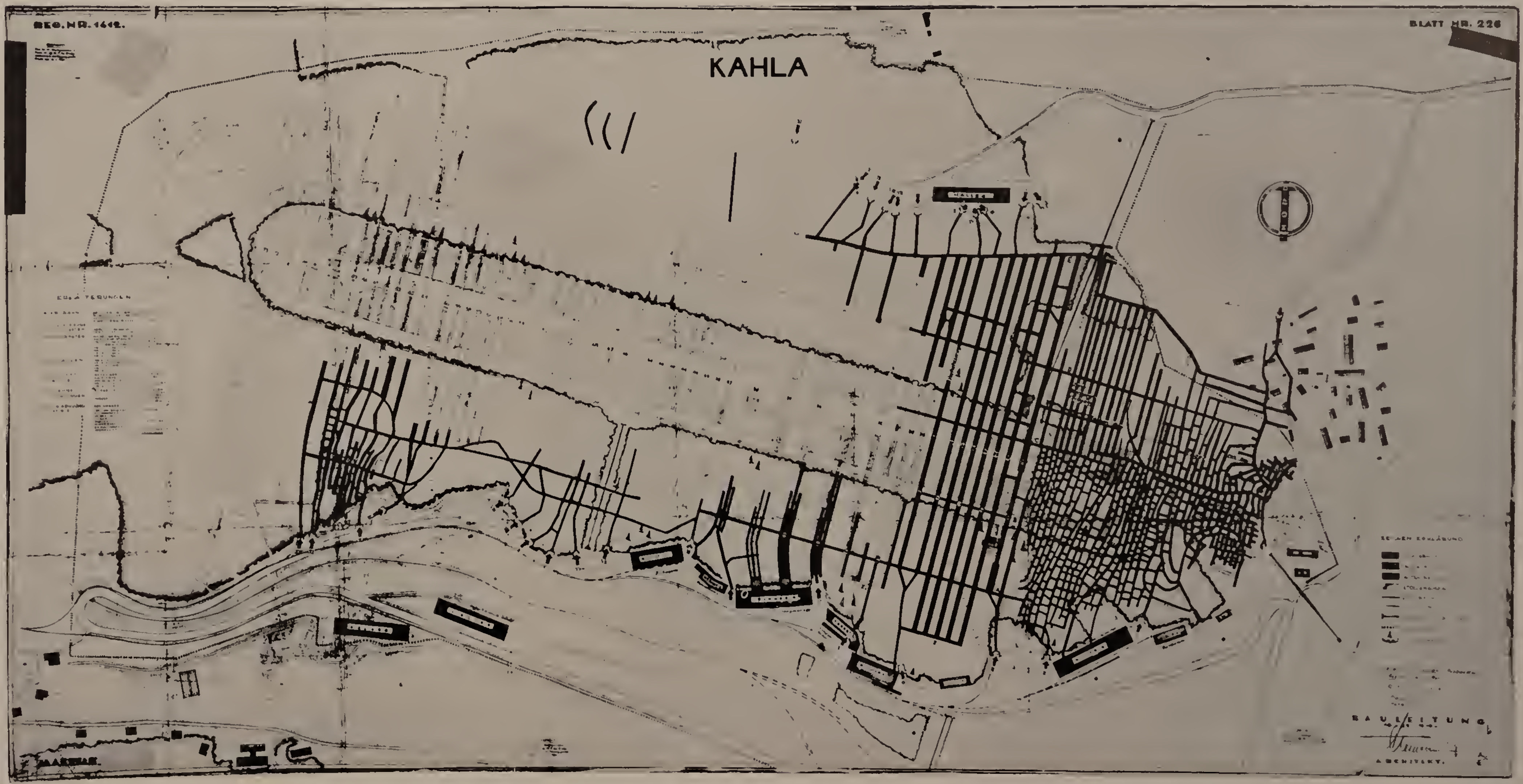


FIGURE 142. Perspective drawing of underground factory at Kahla shown in Fig. 141. This drawing was prepared during World War II to accompany a detailed photo interpretation report on this installation (ACIU P. I. Report No. U. 55 dated 17 April 1945). Compare this drawing with the stereogram in Fig. 141 and the captured tunnel plan in Fig. 143.

FIGURE 143. Captured tunnel plan of the Reimahgbau underground aircraft factory at Kahla, Soviet Zone, Germany, showing the extent of the tunneling operations at the end of World War II. Tunnels excavated are shown in solid black except for a few of the old tunnels in the east sand mine which were not used because of cave ins. Tunnels planned but not excavated are shown in outline. There were 45 tunnel entrances. Check their location on Fig. 141. Note that six are concealed by buildings and others by the thick forest.



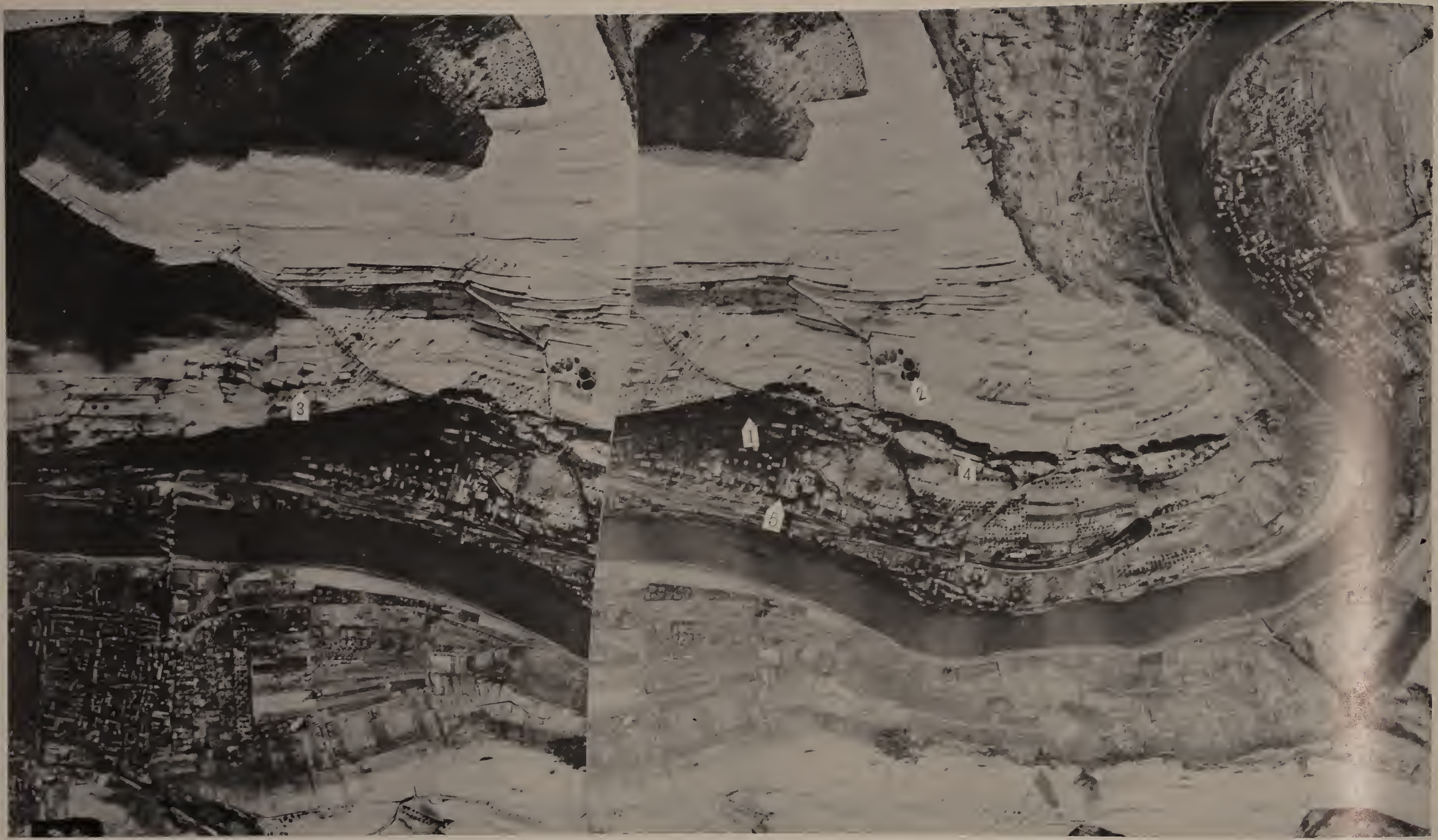
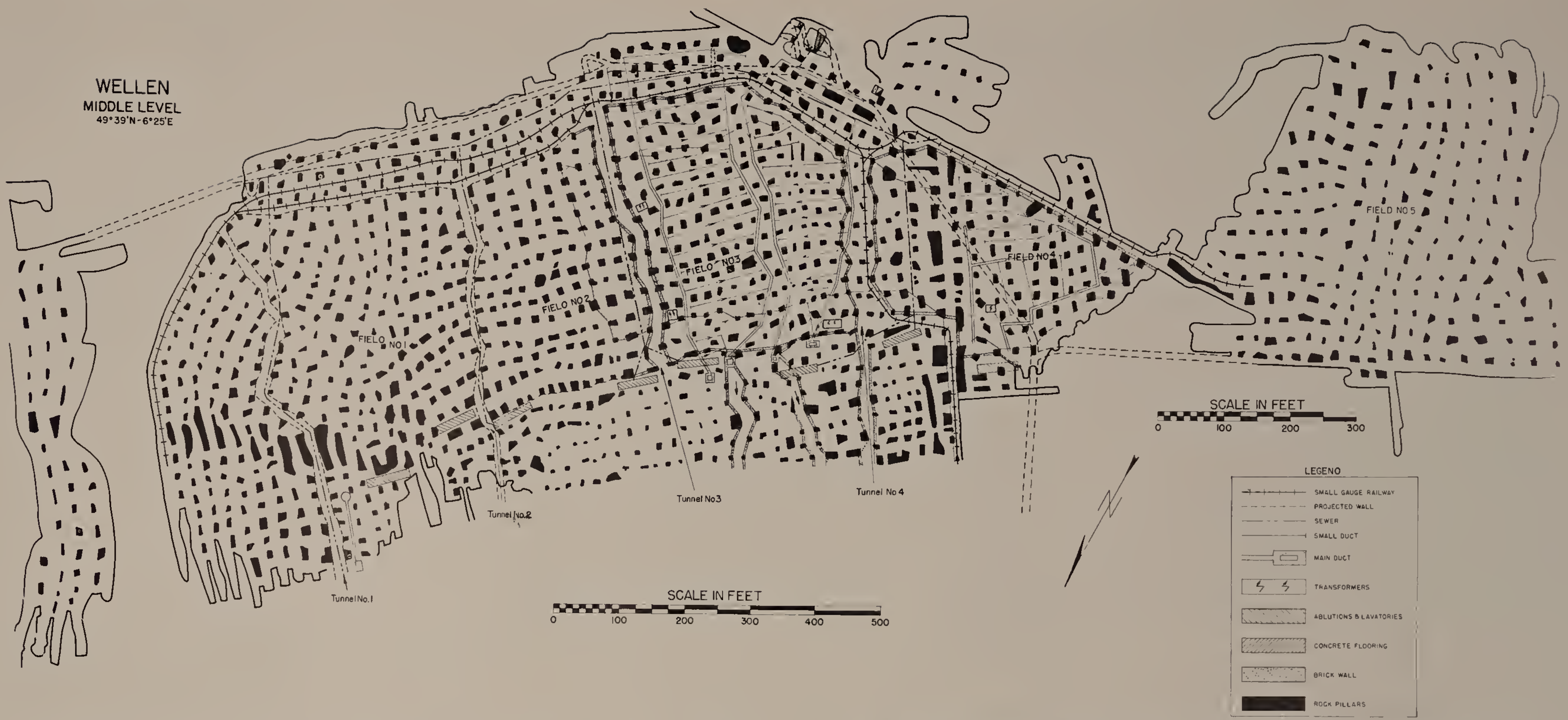


FIGURE 144. Stereogram of the Kugelfischer ball and roller bearing underground factory at Wellen, French Zone, Germany. The factory was installed in the two upper levels of a limestone mine. More than 2,000,000 square feet of floor space were available. Mining was continued on a lower level. The tunnel entrances, which are in the quarry face on the east side of the Moselle River, are exteremely difficult to see because of the poor quality of the photographs and the shadow from the cliff. Tunnel entrance No. 4 on the middle level (1) is shown in Fig. 52. Note the areas of subsidence (2) where roof falls in the upper level broke through to the surface. The best clues to the presence of this underground factory are the new barracks (3) and the new buildings in the quarry near the tunnel entrances (4). Note the cement plant. (5).

Cover: Prints 2009–2010 of Sortie US 31/3852, dated 26 Dec. 1944.



SOURCE ORIGINAL GERMAN DRAWING

FIGURE 145. Plan of the middle level of the limestone mine at Wellen, French Zone, Germany. This is a fairly typical limestone mine. Note that the excavation is one vast open space in which pillars of rock are left to support the roof.

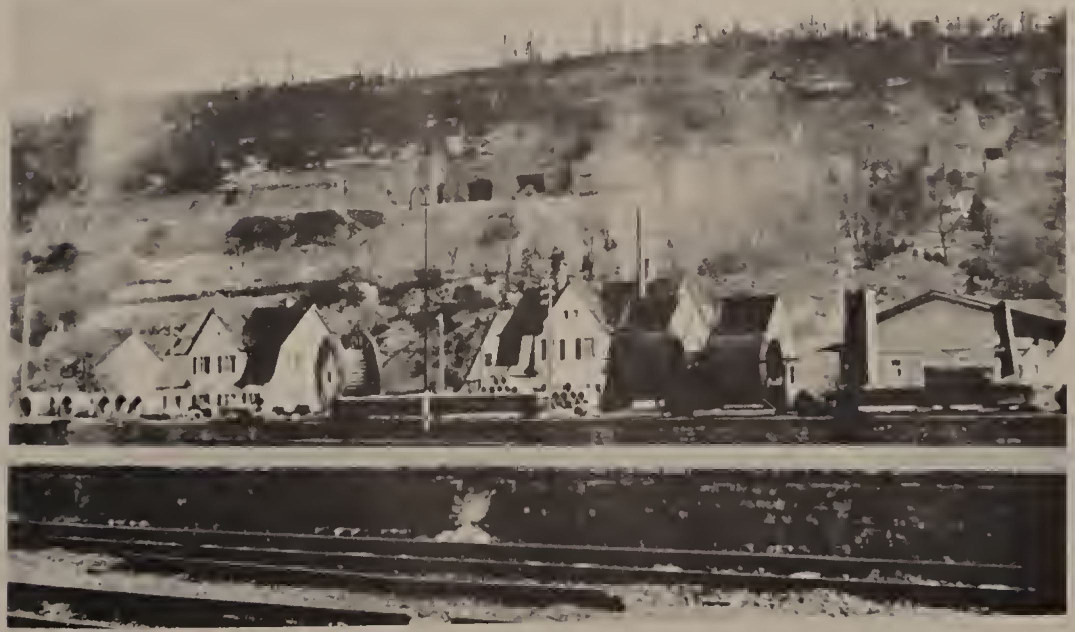


FIGURE 146. View from Wellen of some of the tunnels on the middle level of the limestone mine. Note ventilating fans on the siding. These were probably from the factory. Photo by BBSU Team 42, dated 28 Jan 1946. AF Neg. No. 276584.

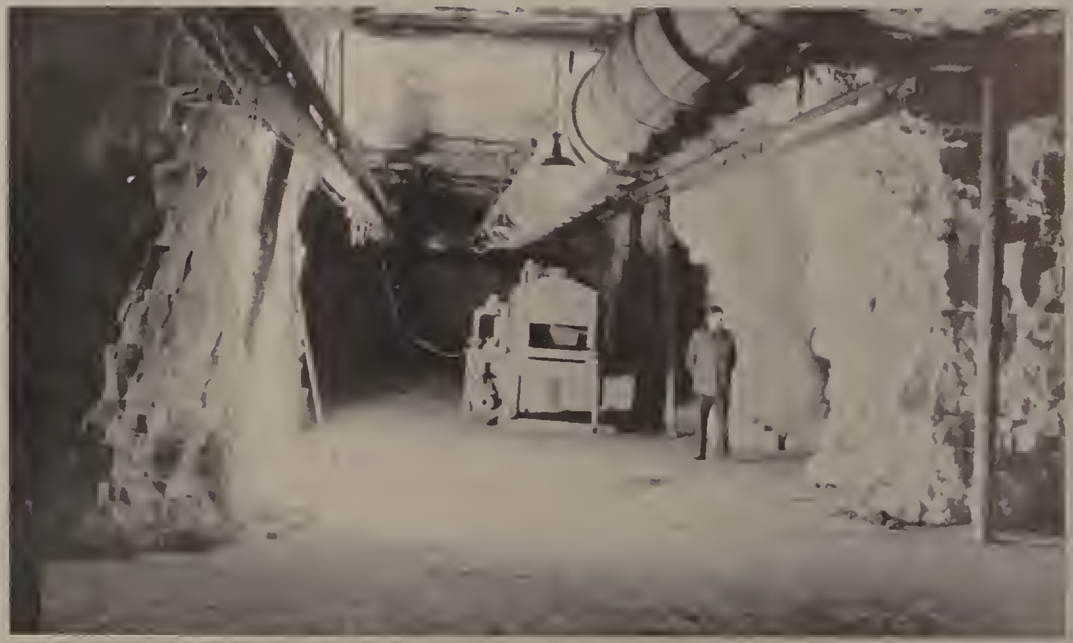


FIGURE 147. Typical interior view in middle level of underground factory at Wellen. Note concrete floor and ventilating ducts. Photo by BBSU Team 42, dated 28 Jan. 1946. AF Neg. No. 276572.

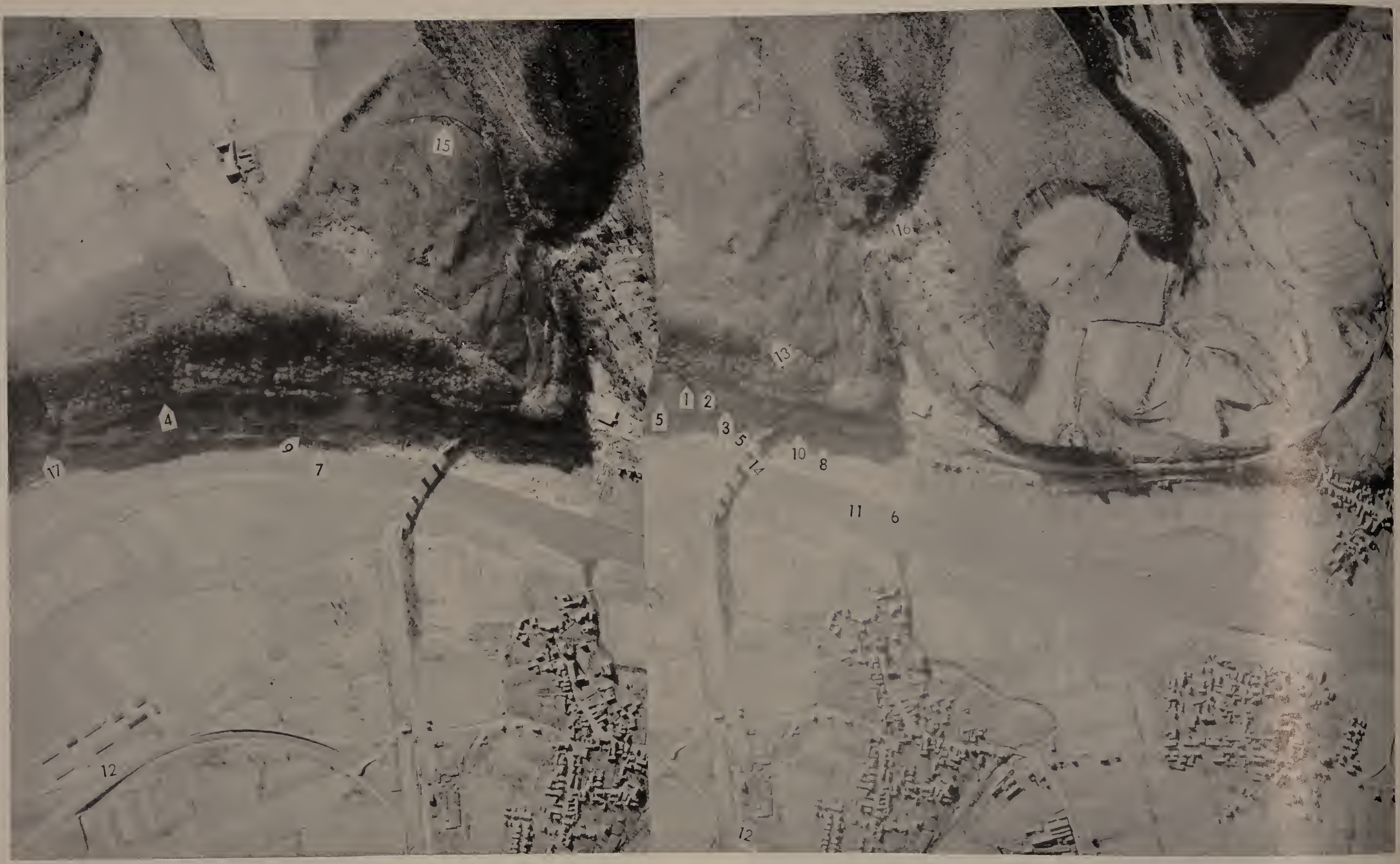


FIGURE 148. Stereogram of the Daimler Benz underground aircraft engine factory Goldfisch in the gypsum mine Friede on the Neckar River at Neckarelz, U. S. Zone, Germany. The underground factory had three entrances, 600,000 square feet of floor space and a maximum overburden of 285 feet. A total of 5,000 employees worked in this factory and a peak production of 1,300 aircraft engines per month was achieved. Photo interpretation of this installation was difficult because of poor quality photographs and the presence of shadow along the hillside where most of the activity was taking place. However, the numerous sorties which covered this area revealed sufficient activity and changes to indicate the conversion of this mine to an underground factory (ACIU P. I. Report No. U. 48, dated 6 April 1945).

(Continued)

FIGURE 148 (Continued). The truck tunnel entrance (1) was new and is indicated by a conveyor which leads from it to the lower road. The original entrance to the mine (2) is difficult to see. Its location is marked by a small building at the top of a long stairway. The third entrance (3) was also new and was at a lower level. It is served by a new standard gauge railway spur. This lower tunnel was very difficult to see. It was connected to the factory by means of an elevator. The road (4) which serves the two upper entrances was improved. There was considerable ground disturbance in the area and the spoil was deposited under the trees, along the hillside and in several spoil heaps (5). Narrow gauge railways (6) were built and used extensively. Barge (7), truck and rail traffic was active and considerable material was stored in the open (8). Several small contractors huts (9), a boiler house (10), a coal storage yard (11), and several labor camps (12) were built. A water tank (13) was located on top of the hill and a small sewage disposal plant (14) was built. Twelve air shafts were present and all except one were well concealed by the forest. This one (15) was an old vertical fresh air shaft. Three of the ventilation shafts were sloping and could be used for emergency exits. Two other smaller gypsum mines in the area (16 and 17) also were being converted into underground factories when the war ended. No production was obtained from them. See Fig. 150 for a plan of Goldfisch.

Cover: Prints 3082–3083 of US 34/3559, dated 15 March 1945.

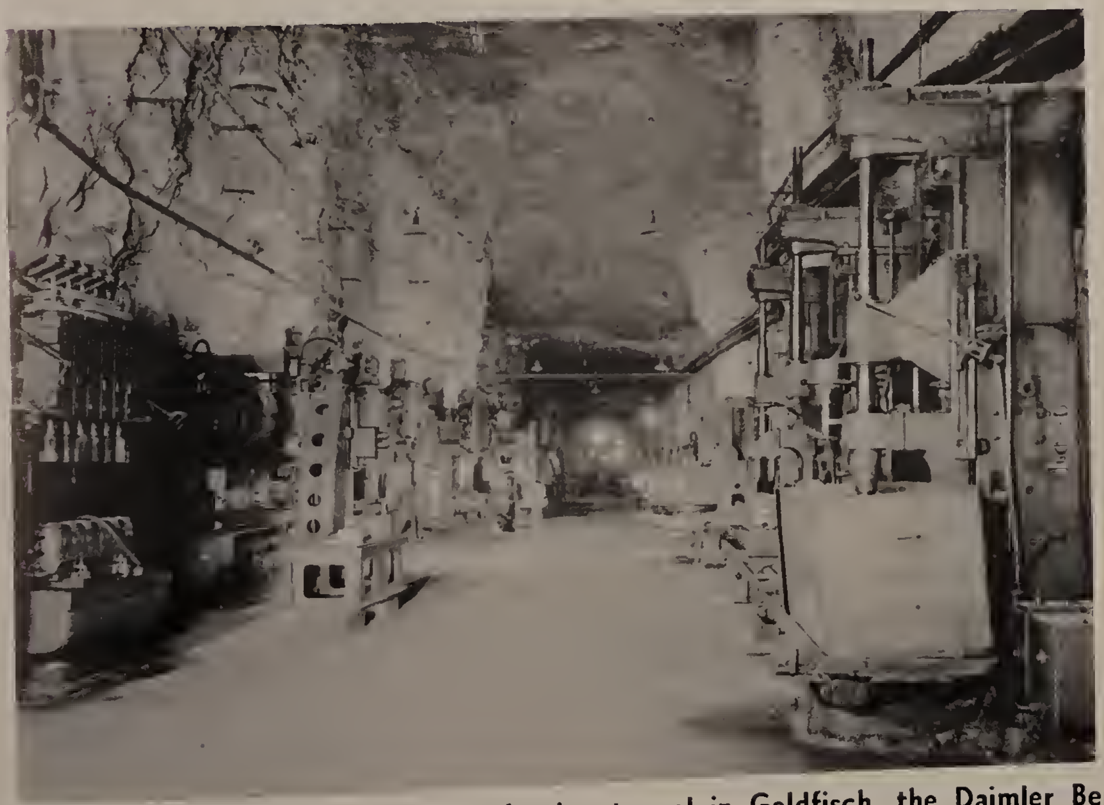


FIGURE 149. Interior view of a production tunnel in Goldfisch, the Daimler Benz underground aircraft engine factory at Neckarelz, U. S. Zone, Germany.

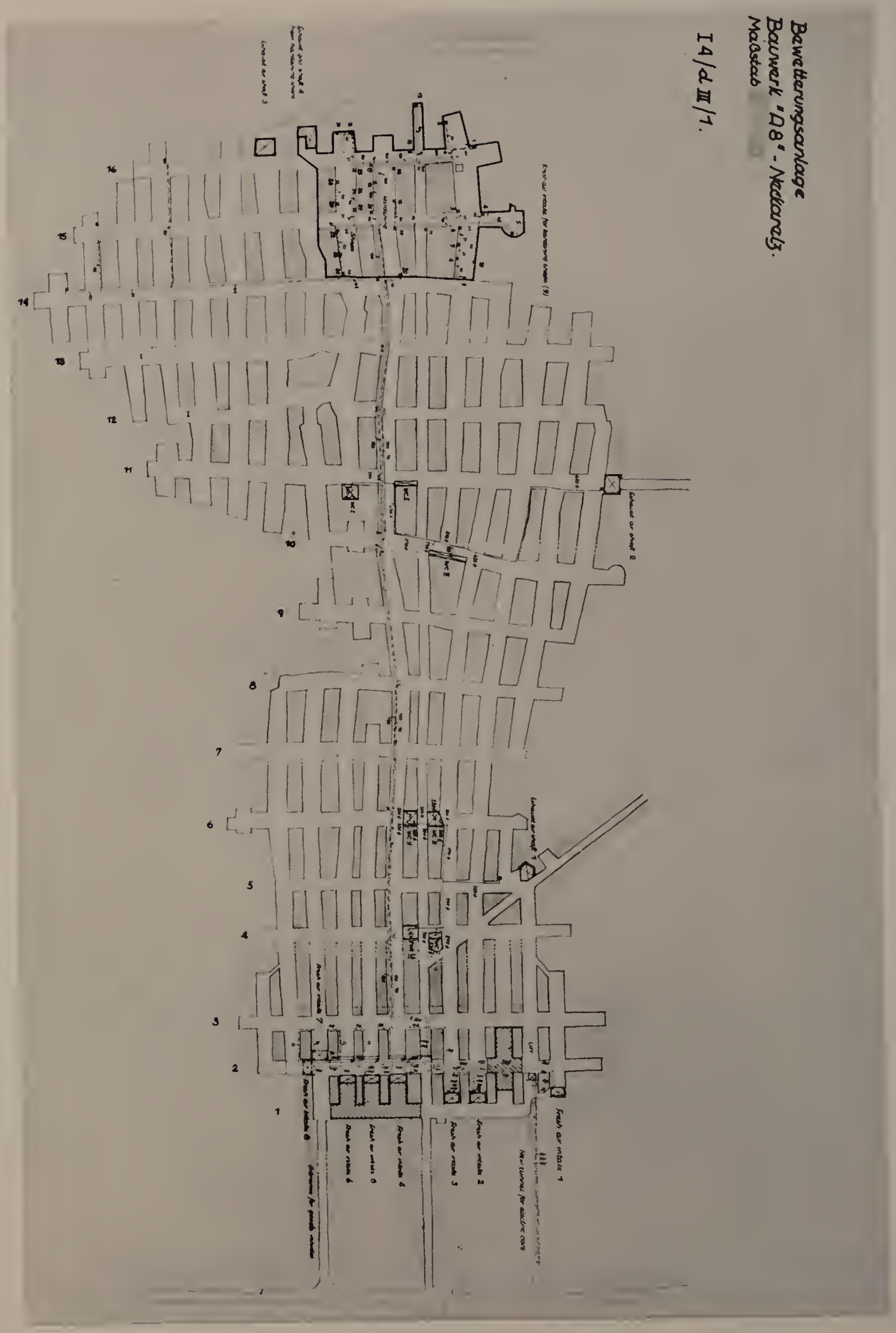


FIGURE 150. Tunnel plan of Goldfisch, the Daimler Benz underground aircraft engine factory shown in Figs. 148 and 149.

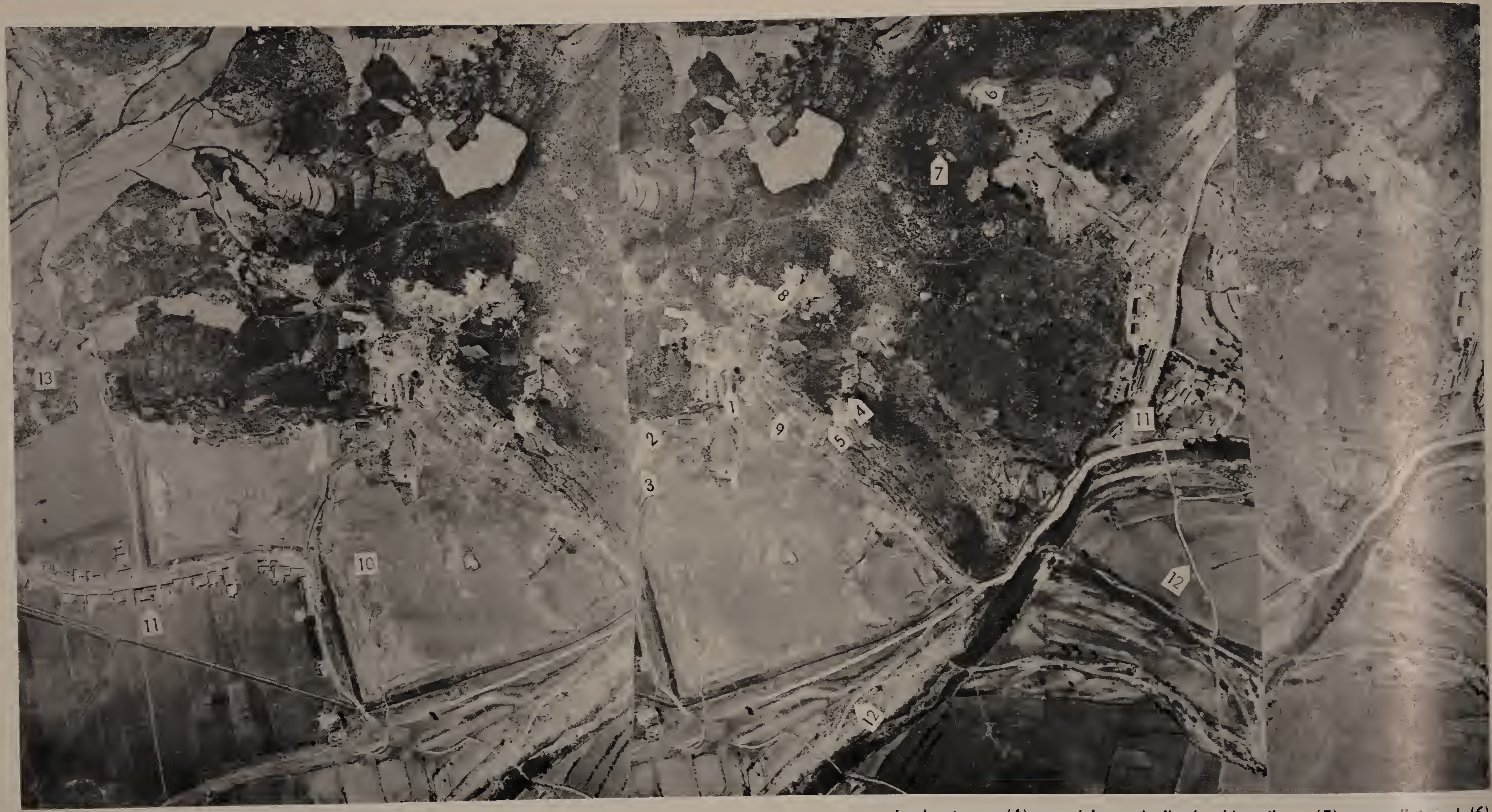


FIGURE 151. Stereogram of an underground arsenal in a zinc mine near Songchon, North Korea. This installation was in U.N. hands in November 1950 and was found to have been producing parts for the PPSH submachine gun, 82 mm mortar, 120 mm mortar and ammunition for the submachine gun. Subsequently this installation was recaptured by Communist forces. The photographs shown above, taken in June 1951, reveal activity which indicates that this installation had not only resumed production but also was being enlarged. Later photographs, taken in December 1951 and shown in Fig. 152, tend to confirm this opinion. Note the following points of interest: the main tunnel entrance to the mine (1); a new entrance (2) or renewed excavation in an old tunnel as indicated by a fresh spoil heap (3), a high level entrance (4) served by an inclined cable railway (5); a small tunnel (6) apparently old; a small tunnel (7) apparently old, which appears to have collapsed a short distance from the entrance; a probable tunnel (8) in an old quarry; foundations to old mine building (9); eroded tailings from the former mining operations (10); buildings and native huts (11) which could be used for housing workers; roads and paths (12) which lead from the mine to native huts; old powder magazines (13). There are many personnel in the area and the paths and roads are well worn.

Cover: Prints 175–177 of Mission 15 TRS R4064B, dated 1 June 1951.

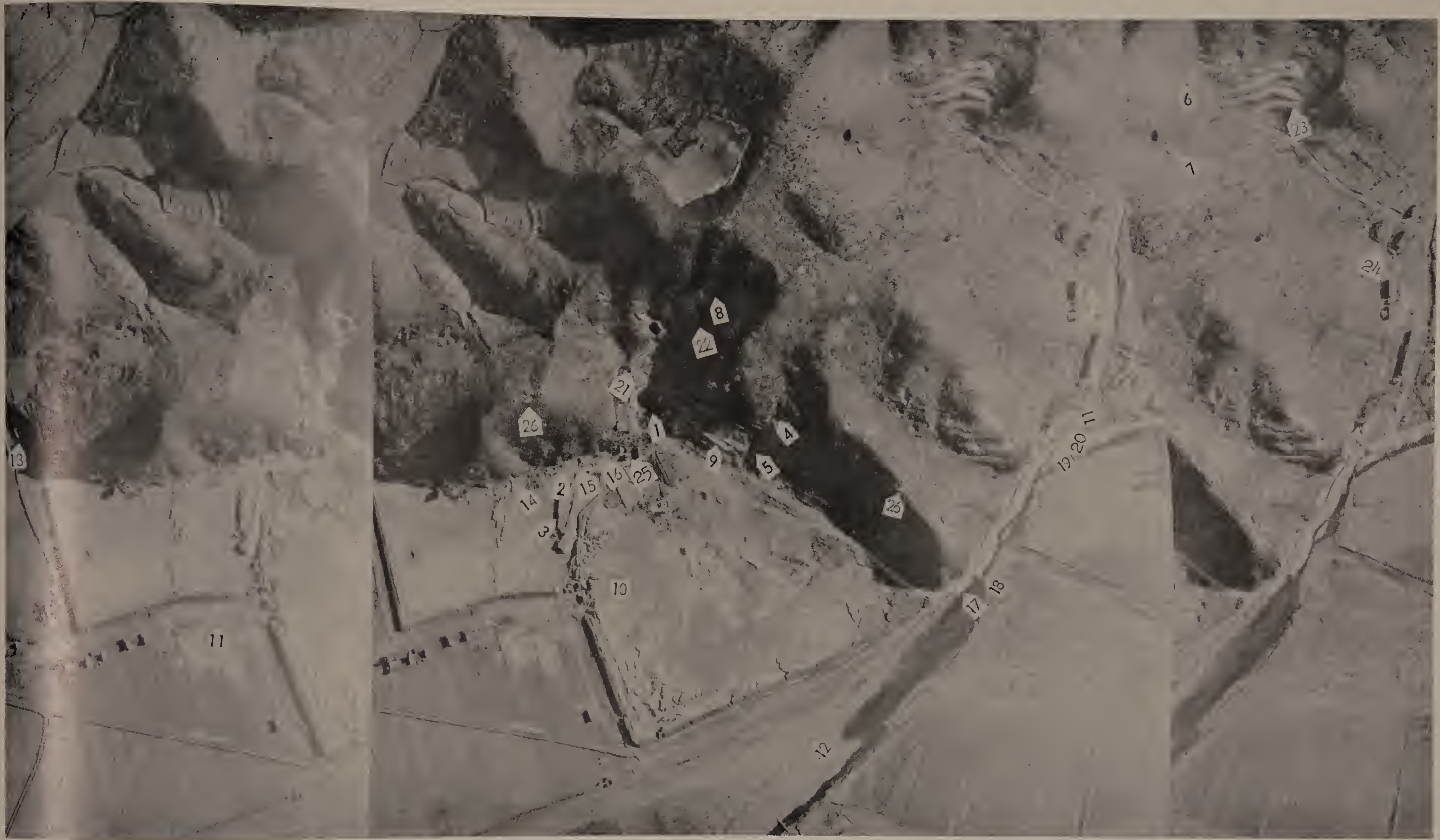


FIGURE 152. Comparative cover of the underground arsenal near Songchon, North Korea, shown in Fig. 151. Note the changes that have occurred: seven new tunnels (14–20), with their attendant spoil heaps; improvement of the road (21) leading to the old quarry; a new building (22) in the quarry; the construction of a rather wide road (23) up to an old tunnel (6) and an increase in the size of the spoil heap at this tunnel; the removal of several native huts (11); the increase in use of the roads and paths (12) which lead to the mine from the native villages; an attempt to camouflage two buildings (24) and the construction of a new building (25). Note the large number of personnel near the tunnel entrances and the antiaircraft installations (26) on the hills. The railway to Pyongyang is located about three miles southeast of the factory. Numerous supply revetments and open air storage of materials (not shown on these photographs) are present along the rail line near Murasi. These may possibly be related to the underground factory.

Cover: Prints 56–458 of Sortie 15 TRS R7225B, dated 15 Dec. 1951.

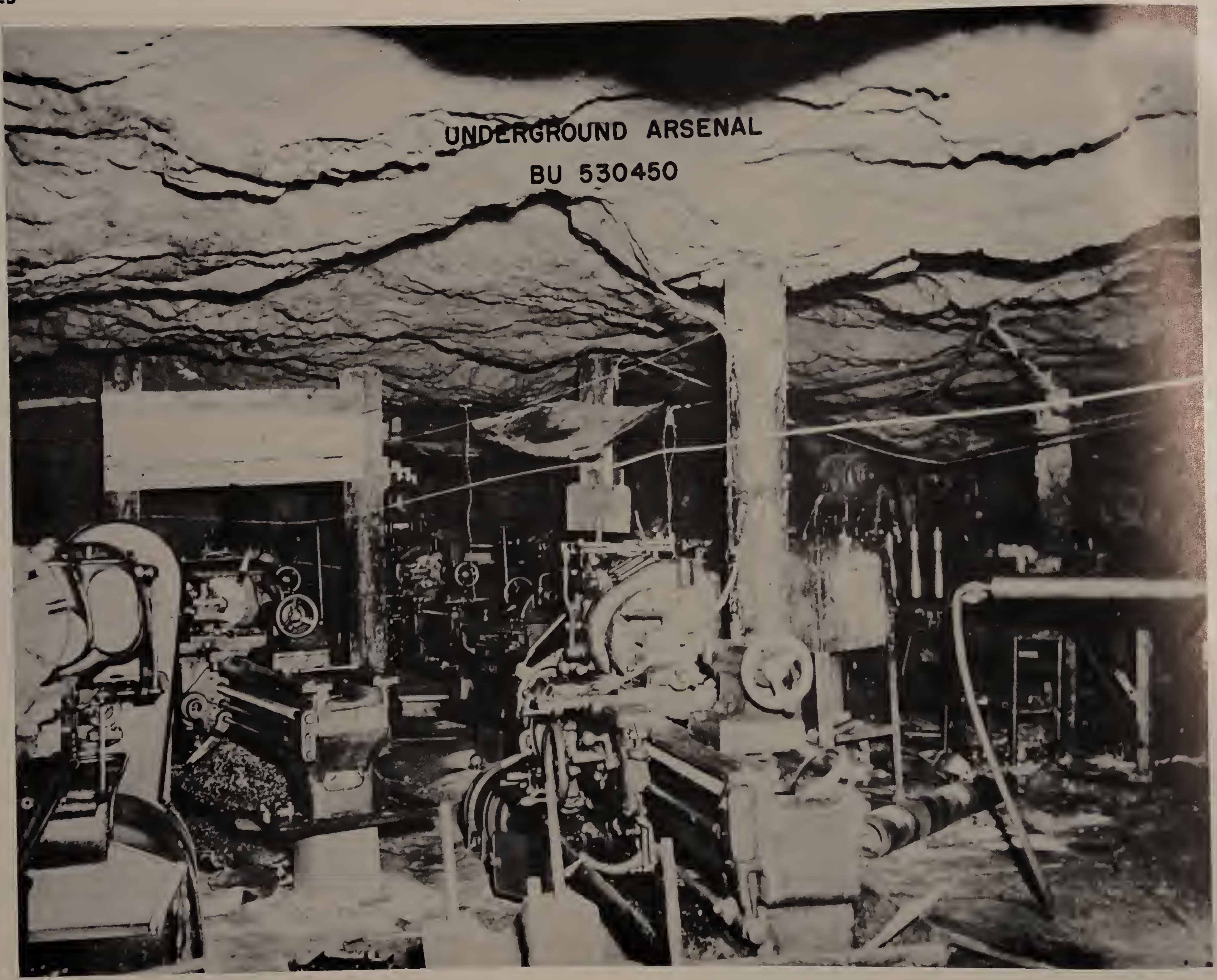


FIGURE 153. Interior view of the underground arsenal near Songchon, North Korea.
U. S. Army Photo 8A/FEC–50–22430, dated 19 Nov. 1950.

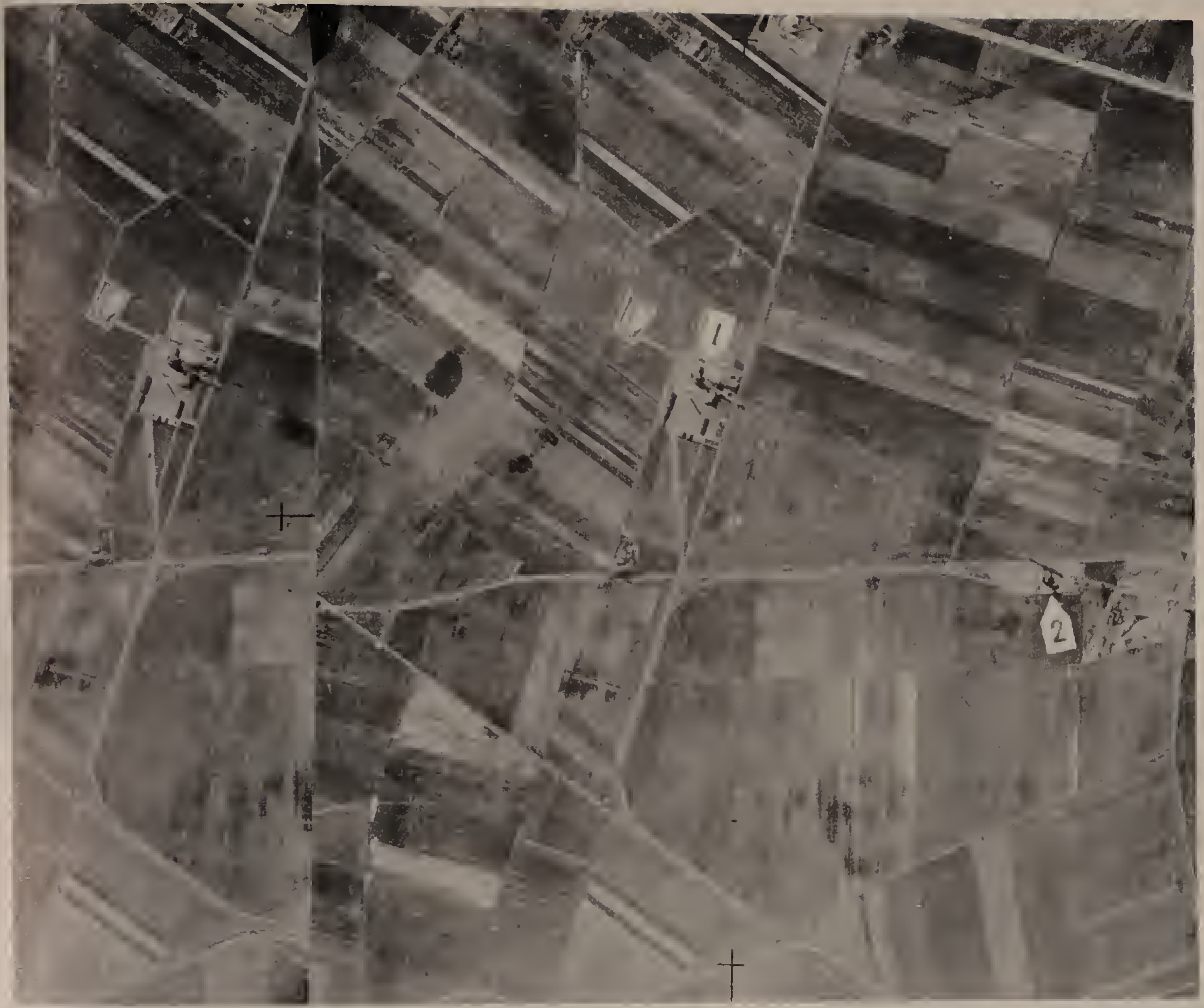


FIGURE 154. Stereogram of an abandoned salt mine near Bernburg, Soviet Zone, Germany. These photographs were taken before the mine was converted to an underground aircraft factory. Note the two shafts (1 and 3) and the lack of activity. Compare these photographs with those shown in Fig. 155, which were taken after the mine was converted to an underground factory.

Cover: Prints 53–54 of Sortie A434/1PRU, dated 25 March 1942.

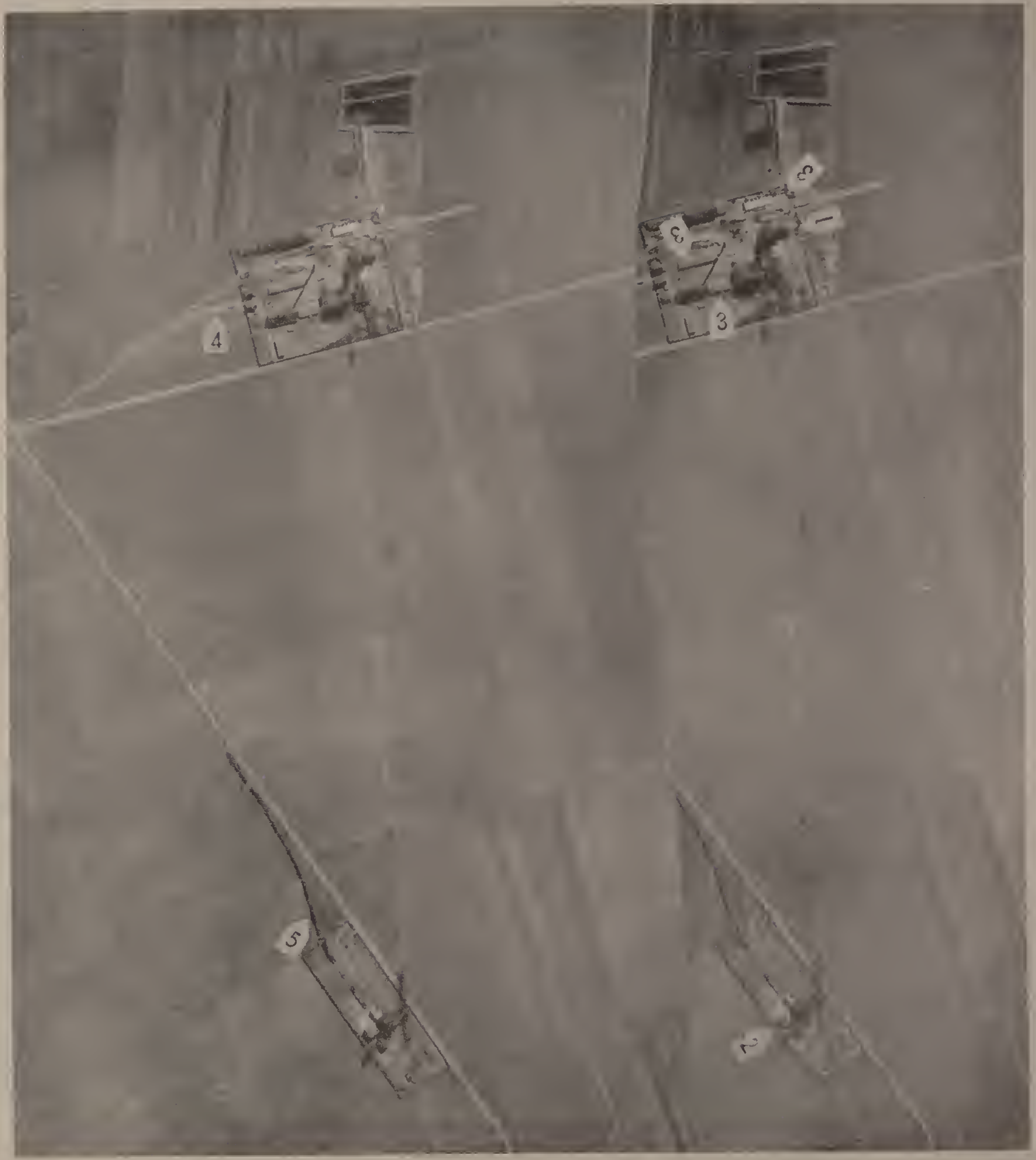


FIGURE 155. Stereogram of the salt mine near Bernburg, Soviet Zone, Germany, shown in Fig. 154. Note the changes and the activity due to the conversion of the mine to an underground factory: new buildings (3), new standard gauge railway spur (4), and the presence of standard gauge railway cars (5). Note that the aerial tramway is not active and that the roof of the terminal building has been removed.

Cover: Prints 3215–3216 of Sortie US7/99B, dated 24 March 1945.

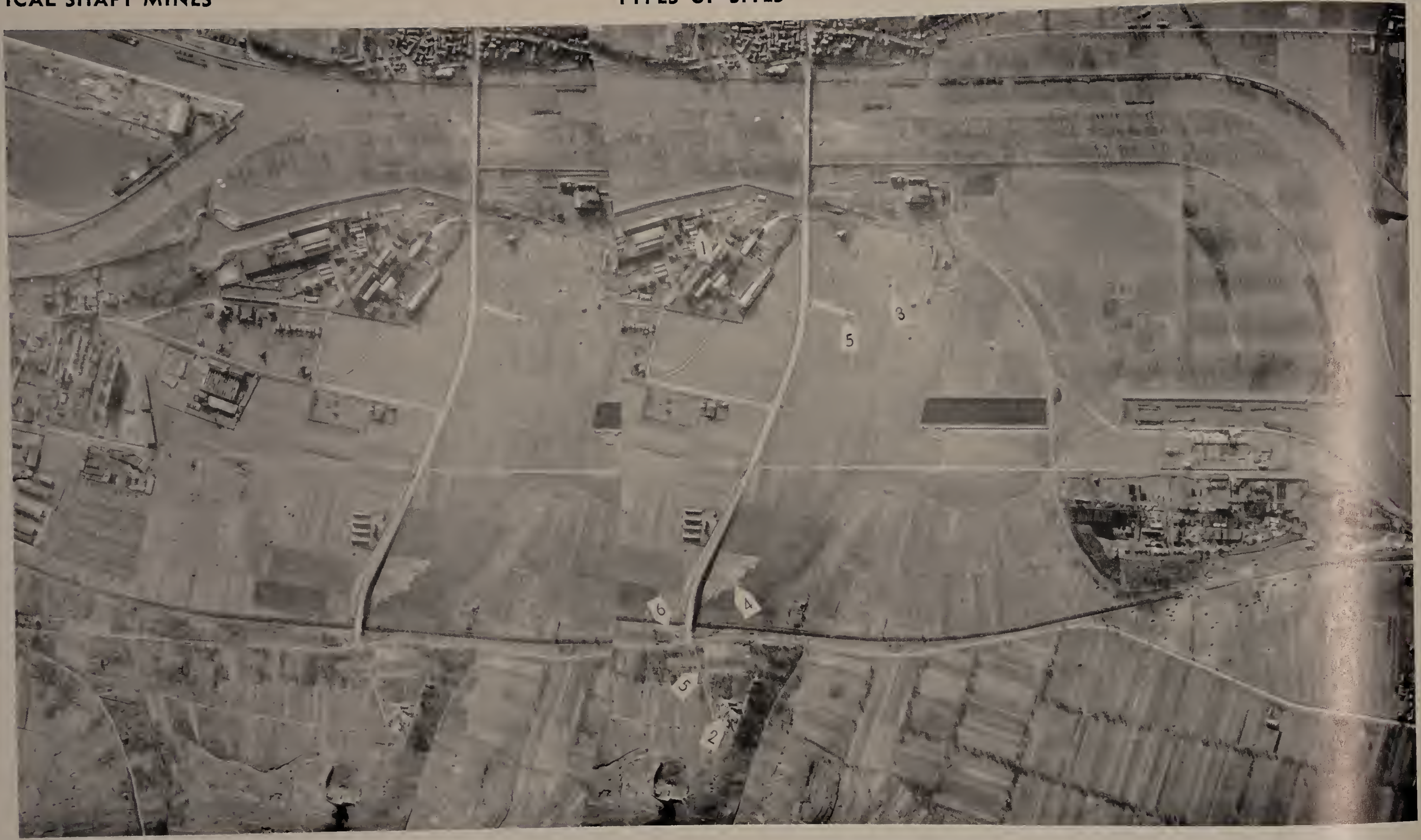
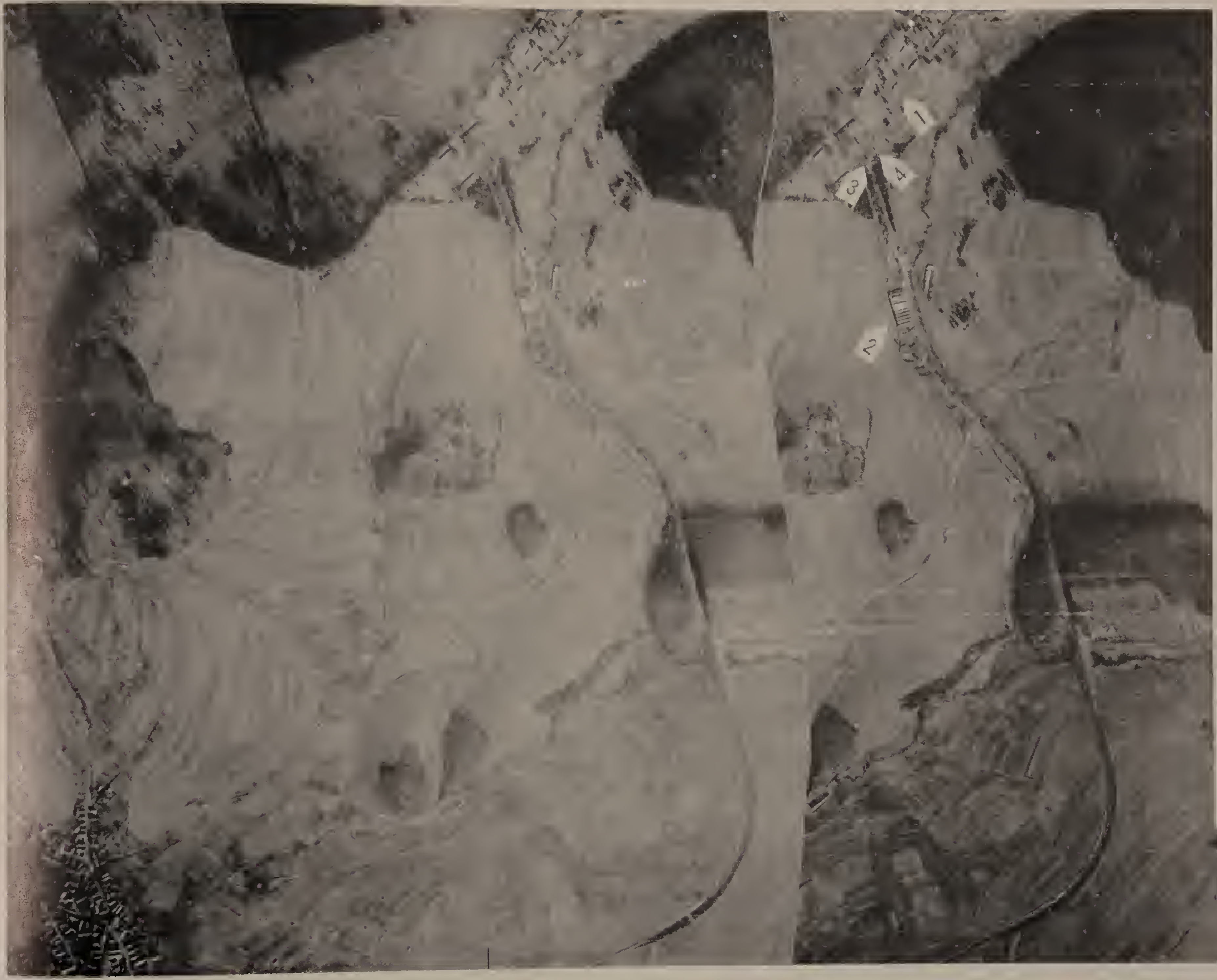


FIGURE 156. Stereogram of the Heilbronn Salzwerk at Heilbronn, U. S. Zone, Germany. This mine is in a bed of salt 131 feet thick and 505 feet below the surface. Some of the tunnels are 45 feet wide and nearly 60 feet high. The mine has a total floor space of 4,304,000 square feet and is entered by a single vertical shaft (1). During World War II part of the mine was allocated to I. G. Farben for the production and storage of chemicals and the repair of valves and fittings for hydrogenation units. The Bosch Co. was allocated another part of the mine for manufacturing purposes. Both companies started modification work and moved in some equipment but the installation of the plants was not completed and no production was obtained. Other tunnels were used for storage purposes by museums and city governments. A new vertical shaft (2) was being excavated and preliminary work was started on a new sloping shaft (3) when the war ended. Note the headframe or derrick (2), its shadow, the disposal of spoil (4), the use of narrow gauge railway (5), and a new cut at the base of the hill (6). This cut is apparently initial work on a horizontal or sloping tunnel which was to intersect the new vertical shaft, similar to the situation at Kochendorf (Figs. 97 and 99).

Cover: Prints 4173–4174 of Sortie 106G/4761, dated 13 March 1945.



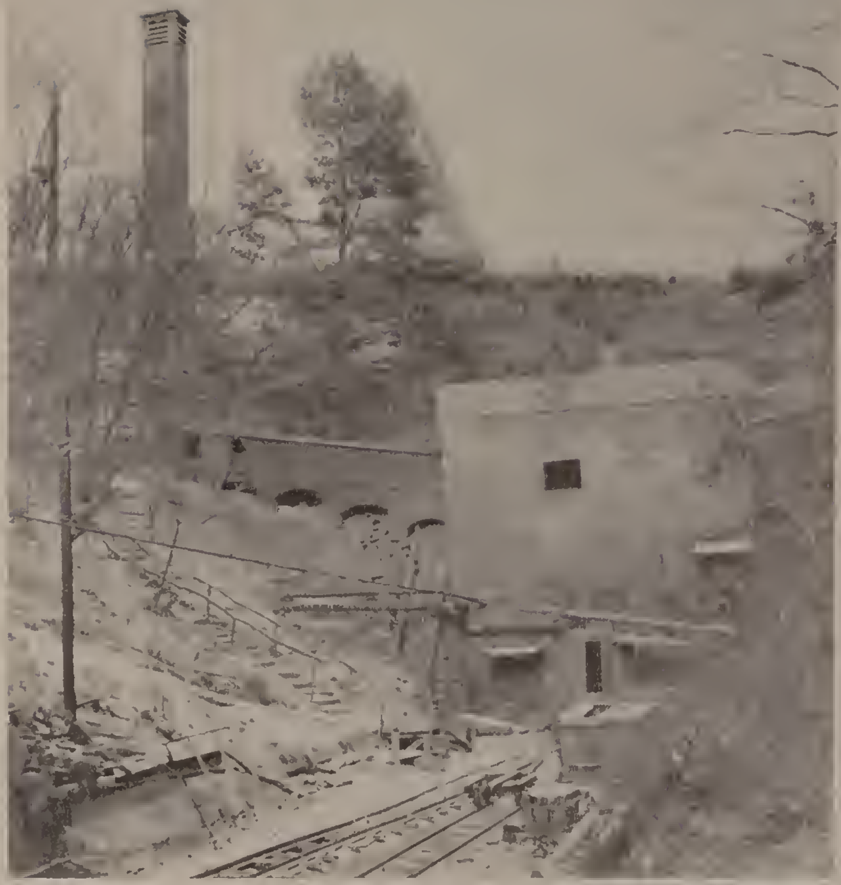


FIGURE 158. South end of the railway tunnel near Hasselborn, U. S. Zone, Germany, that was converted to an underground factory during World War II. Note the ventilation shaft or chimney. An aerial view of this installation is shown in Fig. 157. Photo by A–2, USAFE, February 1946.

FIGURE 157. Stereogram of the Continentale Metall A.G. underground plant in a railway tunnel near Hasselborn, U. S. Zone, Germany. This company was evacuated from Hiddernheim near Frankfort-am-Main and was engaged in the manufacture of aircraft propeller hubs and gears, also experimental work on a six blade propeller. Everything was underground except some offices at the north end (not shown above), and some barracks (1) and a warehouse (2) at the south end of the tunnel. A ground photograph of the ventilation shaft (3) is shown in Fig. 158. The other and larger shaft or chimney (4) was not identified by the field team which inspected this plant. It is probably a chimney for the boiler house. The incoming air was heated in winter. The railway tunnel is 4467 feet long, 15 feet wide and 20 feet high. The track and ballast were removed and a concrete floor laid. A second floor was installed in part of the tunnel and partitions were built to separate different departments and sections such as machining, assembling, testing, chemical laboratory, heat treating, offices, storage and workers mess hall. There were 1,527 employees. The factory was air conditioned.

Cover: Prints 4017–4018 of Sortie 106G/4369, dated 17 February 1945.

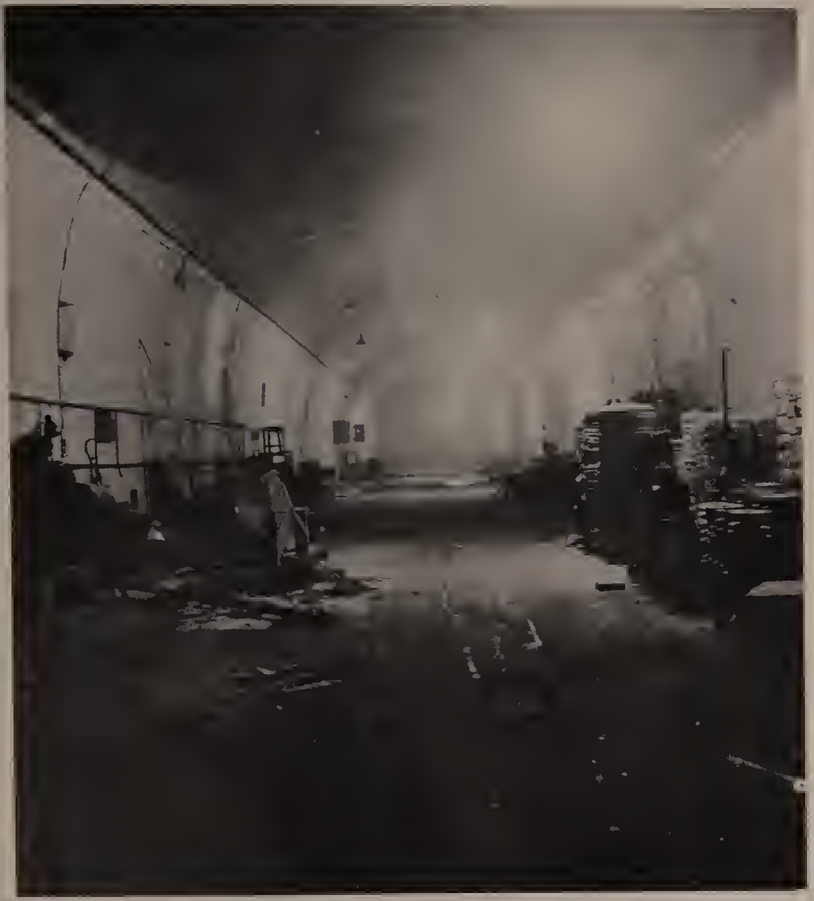


FIGURE 160. Interior view of the autobahn tunnel near Wiesensteig, U. S. Zone, Germany. The portion of the tunnel shown above was utilized by Daimler Benz for the manufacture of aircraft superchargers. Photo by A–2, USAFE, February 1946.

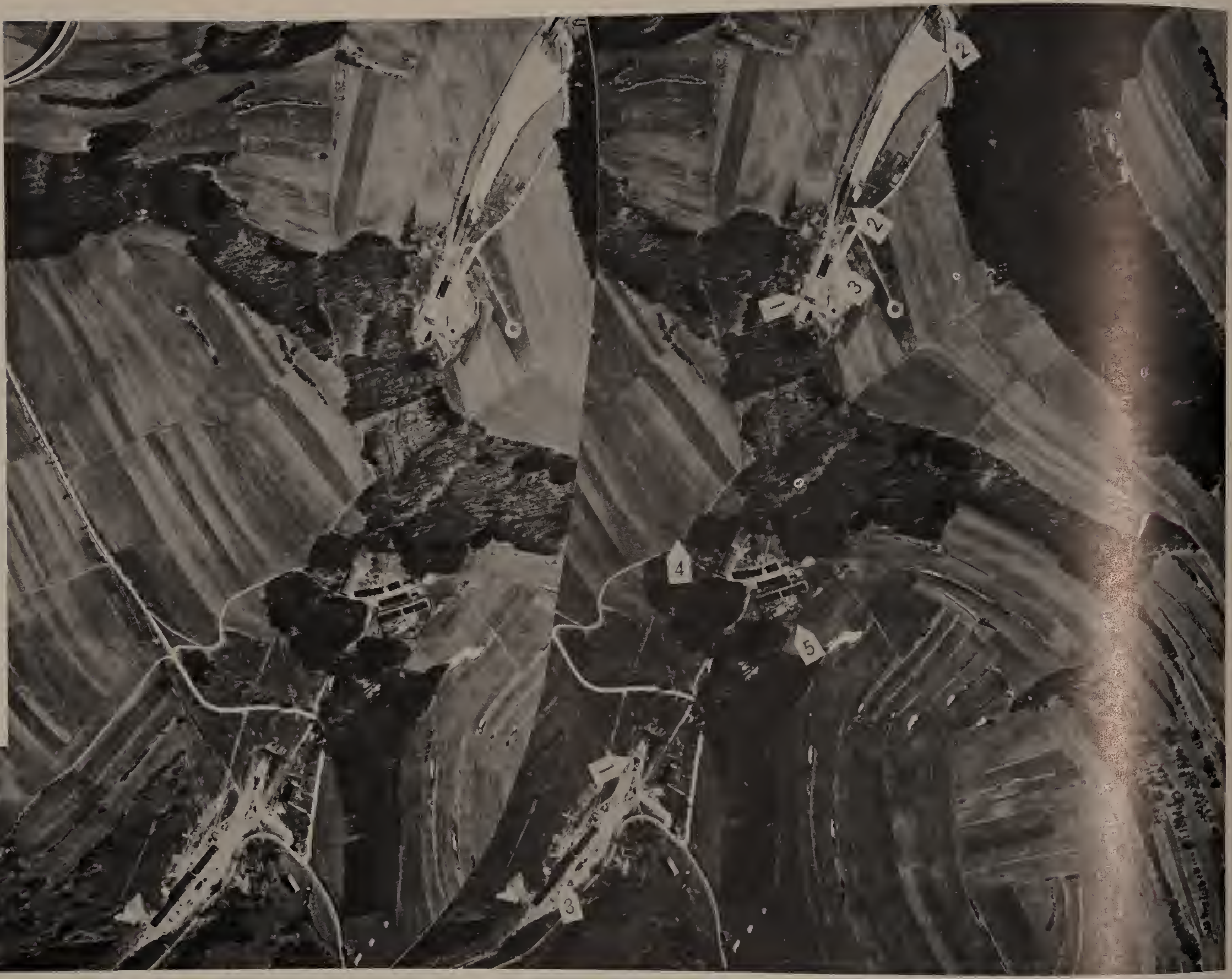


FIGURE 159. Stereogram of an incompleted highway tunnel near Wiesensteig, U. S. Zone, Germany, that was utilized for manufacturing purposes during World War II. Excavation and construction work on the tunnel and the road was halted in 1939. Modification of the tunnel for manufacturing purposes was commenced in October 1943 and completed for the most part in July 1944. The ends of the tunnel were bricked up, blast walls (1) were built to prevent skip bombing, the limestone rock was partially camouflaged with green paint (2), several buildings (3) were erected and a connection was made to a power line (4). The barracks on top of the hill (5), which were built before the war for the highway construction workers, were used for housing some of the factory workers. Note the three barracks enclosed by a wire fence. These were used for the slave laborers, mostly Russians. The tunnel is lined with concrete except for a section in the middle 81 feet long which was not completely excavated. This tunnel is 1,970 feet long, 31 feet wide and 31 feet high. Three separate firms were allocated space in the tunnel. The Heller Co. produced torpedo pumps and parts for machine tools, Daimler Benz produced aircraft superchargers and Kuknle, Kopp, and Kausche planned to produce gas turbine wheels and blades but did not get into production.

Cover: Prints 3244–3245 of Sortie 106G/5039, dated 23 March 1945.

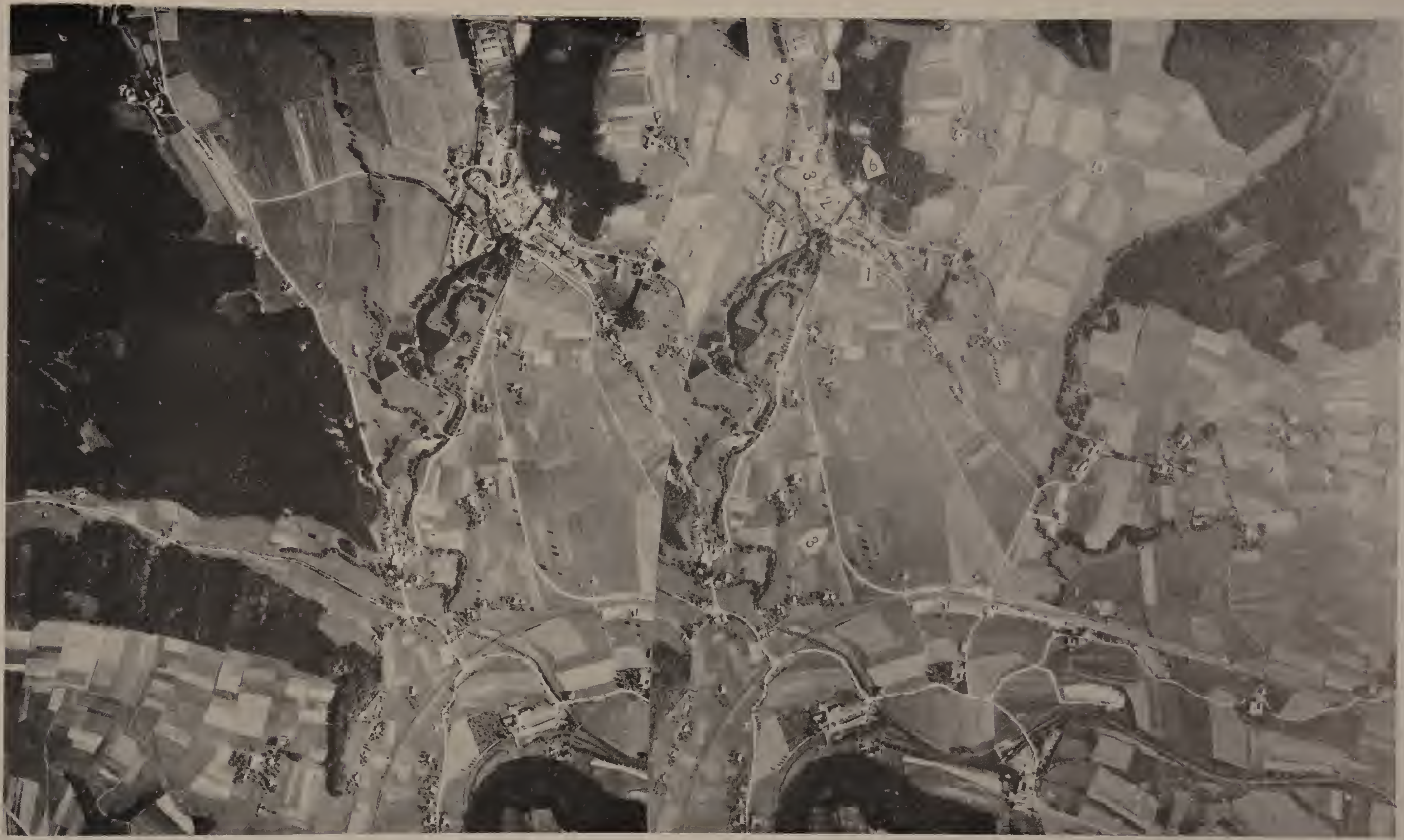


FIGURE 161. Stereogram of an underground liquid oxygen plant in extended beer storage tunnels at Redl/Zipf, U. S. Zone, Austria. This plant produced 80 tons of liquid oxygen per day. Research and testing of V–2 rocket engines also was done here. There are at least four entrances, one of which may be entered from the brewery (1). The main entrance to the factory (2) is protected by a massive concrete structure and is served by a standard gauge railway spur (3). Spoil from the new tunnels was dumped at the base of the hill (4) beside a small labor camp (5). The V–2 rocket engine test facility on top of the hill (6) has two exhaust vents and is connected to the factory below by an elevator. The maximum thickness of the rock overlying the tunnels is 116 feet. The factory has a floor space of 57,450 square feet, and the tunnels average 20 feet in width and 20 feet in height.

Covers: Prints 4162–4163 of Sortie P578/683 Sq dated 16 August 1944.

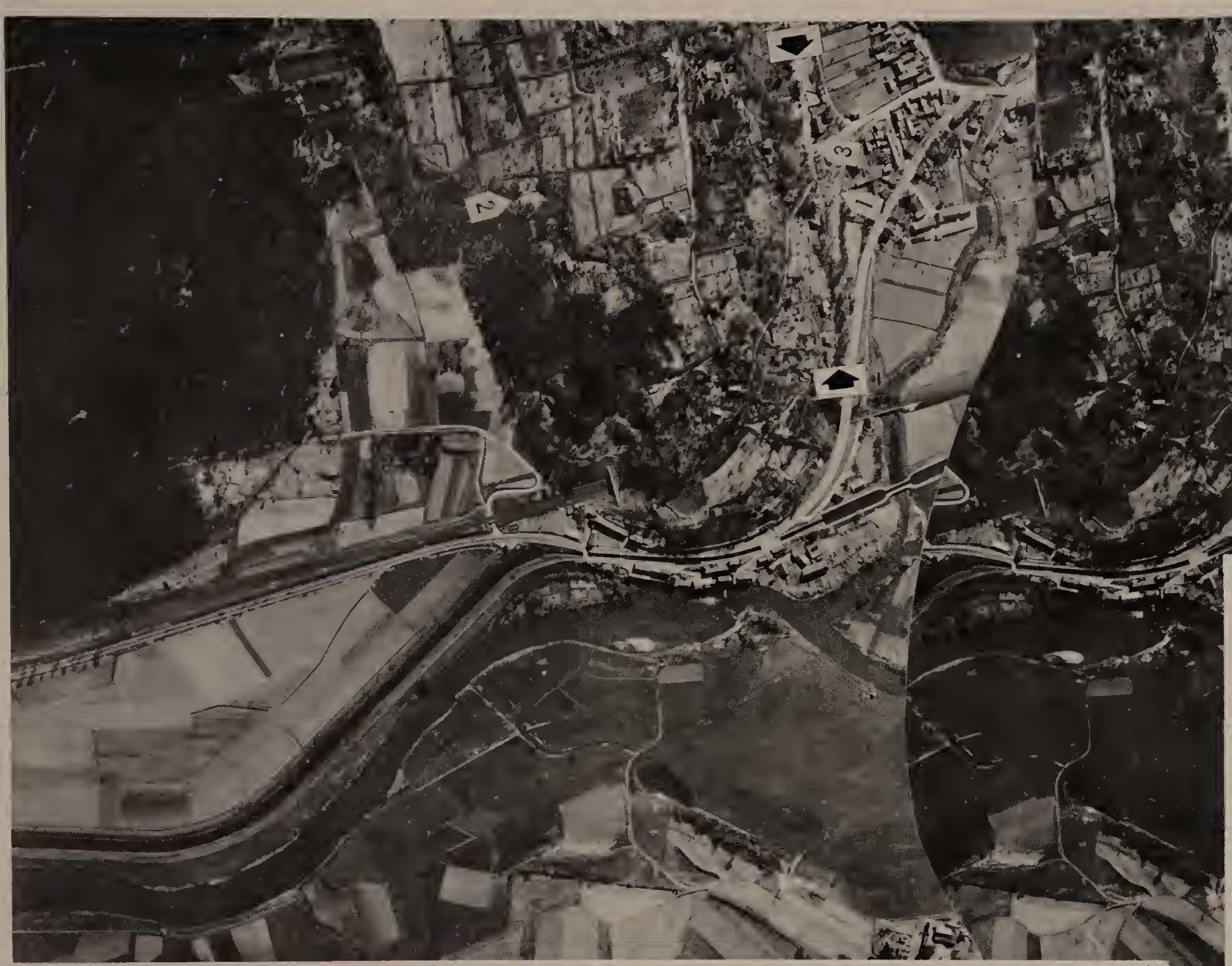


FIGURE 162. Stereogram of a group of mushroom tunnels in a hill, the Burgberg, at Erlangen, U. S. Zone, Germany. There are about 20 private tunnels, known locally as kellers, in the Burgberg. Of these, the entrances to some 14 kellers are in the photographs shown above (between the two arrows). See Fig. 164 for their exact location. These kellers provide a total of about 160,000 square feet of underground floor space. The maximum overburden is 130 feet. Siemens-Reiniger A.G. began modification of three kellers for the manufacture of automatic pilots and radio directional equipment but did not get into production by the end of the war. Some of the tunnels had to be cleaned out and some excavation work was done. The spoil (1), was dumped nearby. One tunnel extended all the way through the hill (2). Note the well worn and disturbed appearance of the area near the tunnel entrances (3) due to the construction work involved in converting these tunnels into an underground factory.

Cover: Prints 4150–4151 of Sortie 104W/C72, dated 11 April 1945.

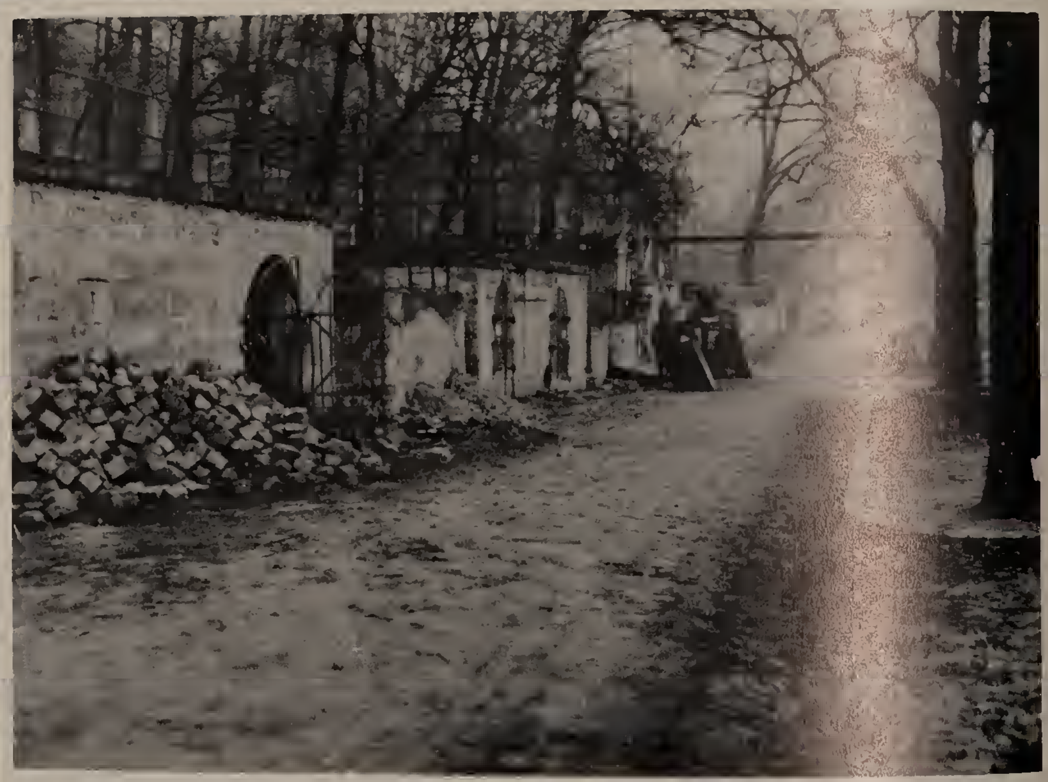


FIGURE 163. View of the entrances to several of the tunnels in the Burgberg, at Erlangen, U. S. Zone, Germany, shown in Fig. 162. Tunnels of this type, which are fitted with doors and enter the hill through a wall, are common in Europe and are used extensively for the storage of potatoes and other vegetables as well as for raising mushrooms. Old tunnels of this type are oftentimes concealed by trees and are difficult to see on aerial photographs. Photo by A–2, USAFE, 1946.

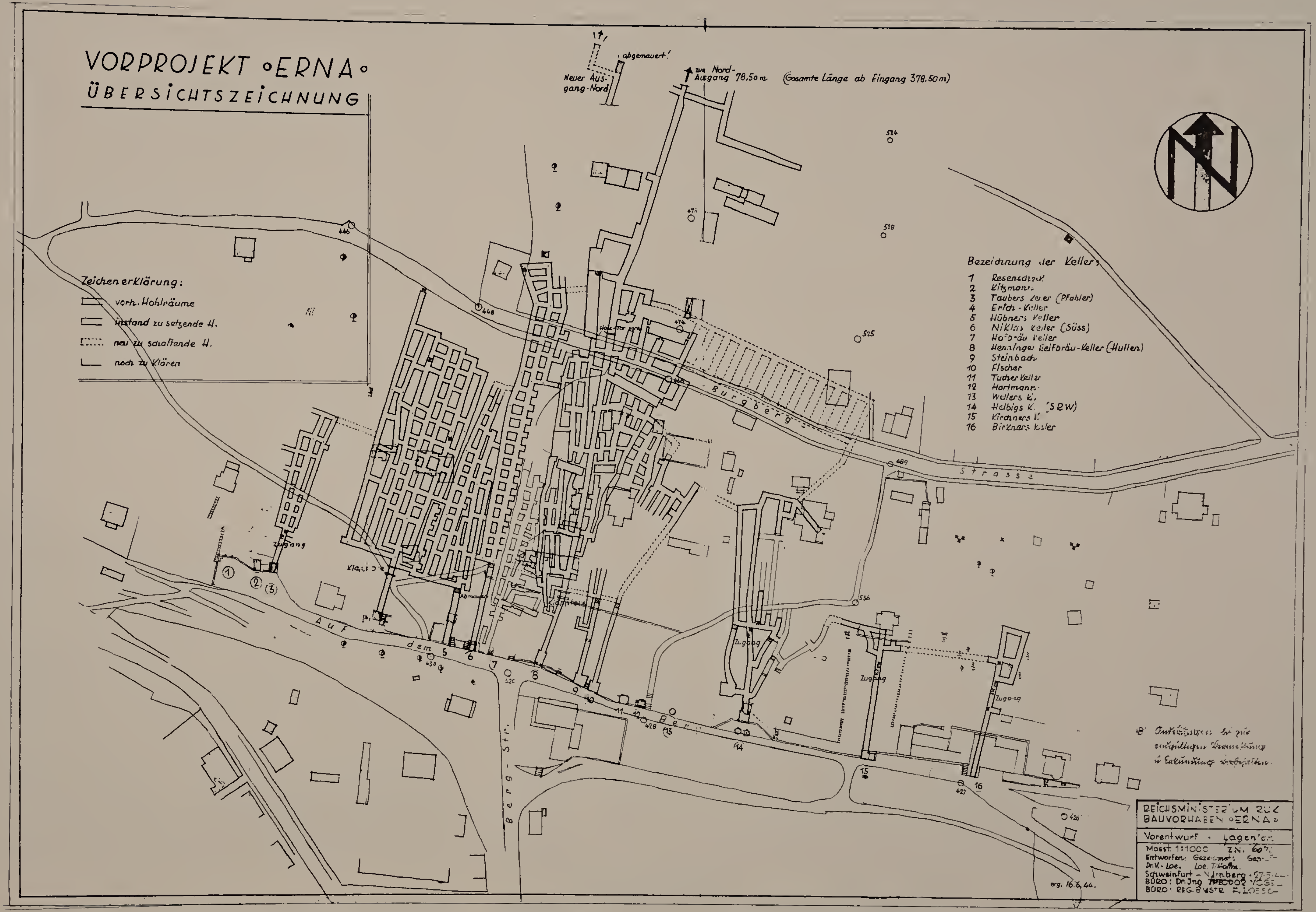


FIGURE 164. A plan of the tunnels in the Burgberg, at Erlangen, U. S. Zone, Germany, dated 16 June 1944. This plan was prepared for the Siemens-Reiniger underground factory, code name Erna. An aerial view of kellers 1–14 is shown in Fig. 162. AF Neg. No. 276752.

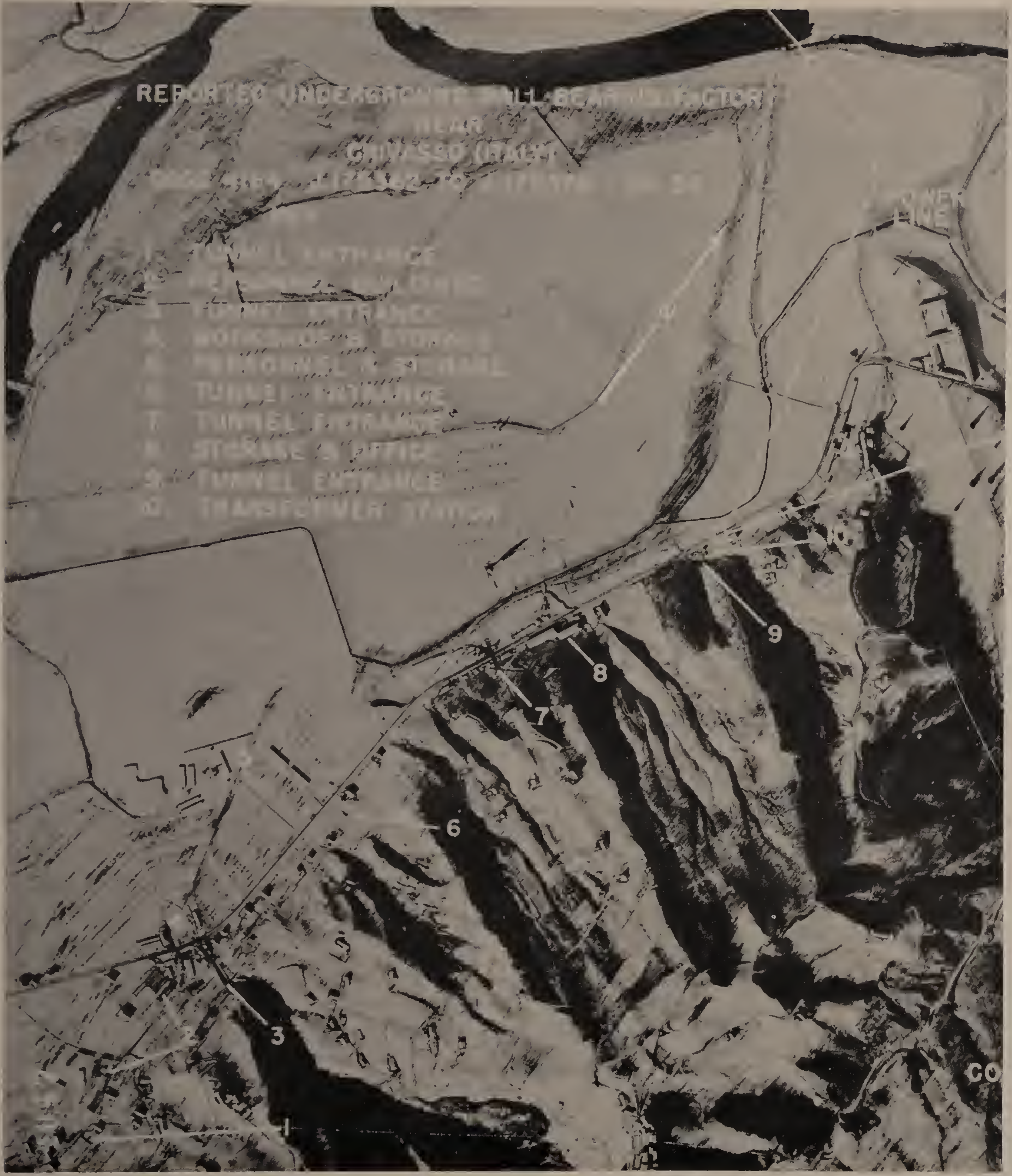


FIGURE 165. An annotated print which accompanied Photo Intelligence Report No. 3 HI 95 (S), 3rd Photo Tech Sqdn., 3rd Photo Group Recon, prepared during World War II. A subsequent ground check confirmed the interpretation. The underground ball bearing factory was set up in a water tunnel built for a hydroelectric power plant. This tunnel lies about 550 feet east of and approximately parallel to the main road. Access to the factory was by means of the five small tunnels indicated (1, 3, 6, 7, 9). Note the spoil heaps opposite tunnels 7, 8 and 9. The water tunnel is five miles long, 35 feet wide and 20 feet high. The factory occupied about three quarters of a mile of it. About 1,500 workers were employed here. They lived in the temporary buildings nearby. Several air shafts provided ventilation.

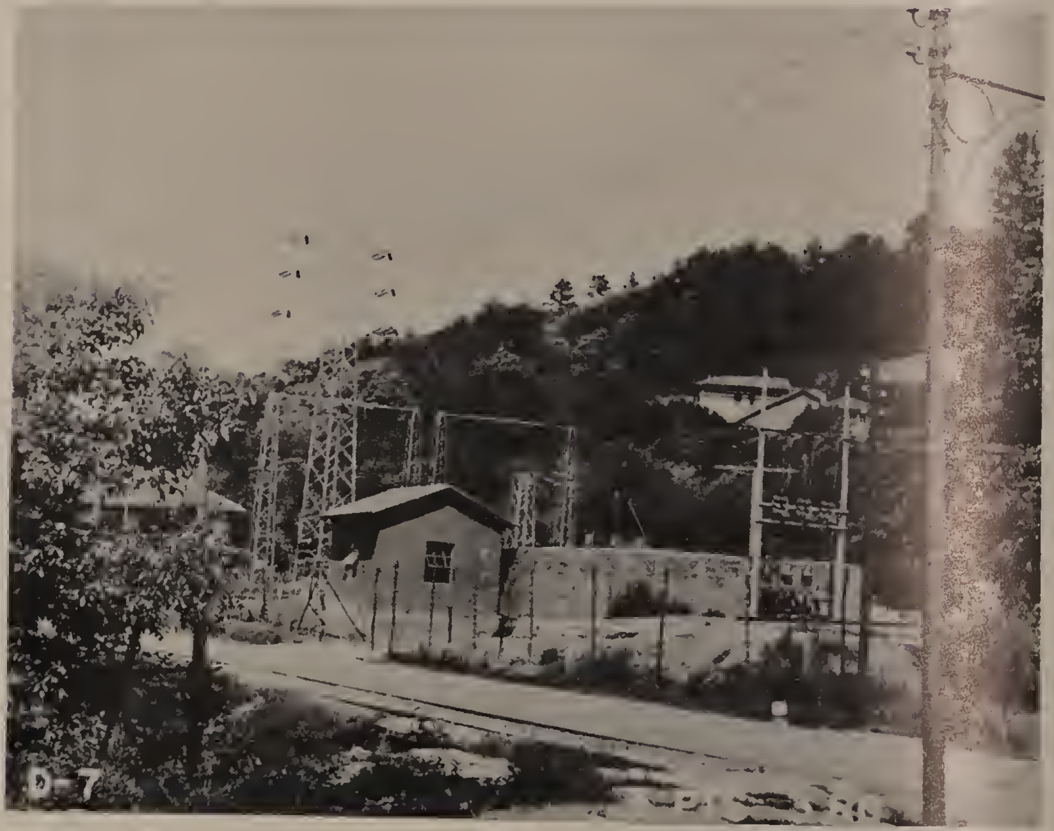


FIGURE 166. Ground view of the transformer station at the underground ball bearing factory in a water tunnel near Chivasso, Italy, shown in Fig. 165. Photo by 3rd Photo Tech Sqdn, 3rd Photo Group Recon. AF Neg. No. 276579.

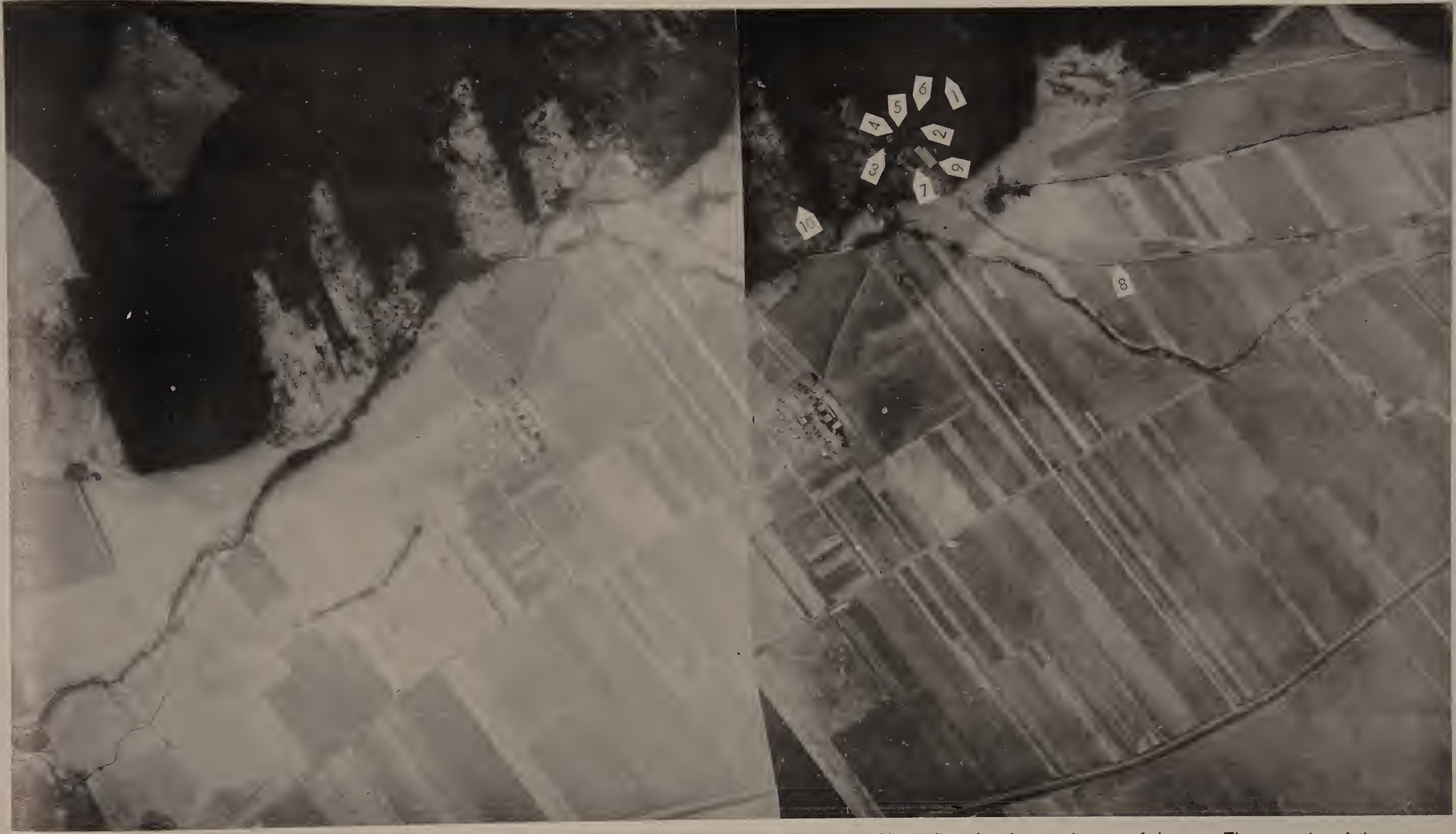


FIGURE 167. Stereogram of a Junkers underground factory built inside a natural cave near Uftrungen, Soviet Zone, Germany. The factory produced landing gear for Ju 88 and Ju 188 aircraft. The cave, the Heimkehle Hoehle, was a tourist attraction before the war and is claimed to be the largest gypsum cave in Germany. The old cave entrance (1) is well concealed by trees. The tourist exit tunnel (2) was used as a utility tunnel for steam and water pipes. The prewar guest house and restaurant (3) is indicated on large scale maps of the area. The conversion of the cave to a factory involved the construction of two new tunnel entrances (4 and 5), a boiler house (6), a pond (7), a standard gauge railway spur (8), a transhipment and storage building (9) and two ventilation shafts, one of which is indicated (10).

Cover: Prints 4016–4017 of Sortie 3981, dated 28 December 1944.

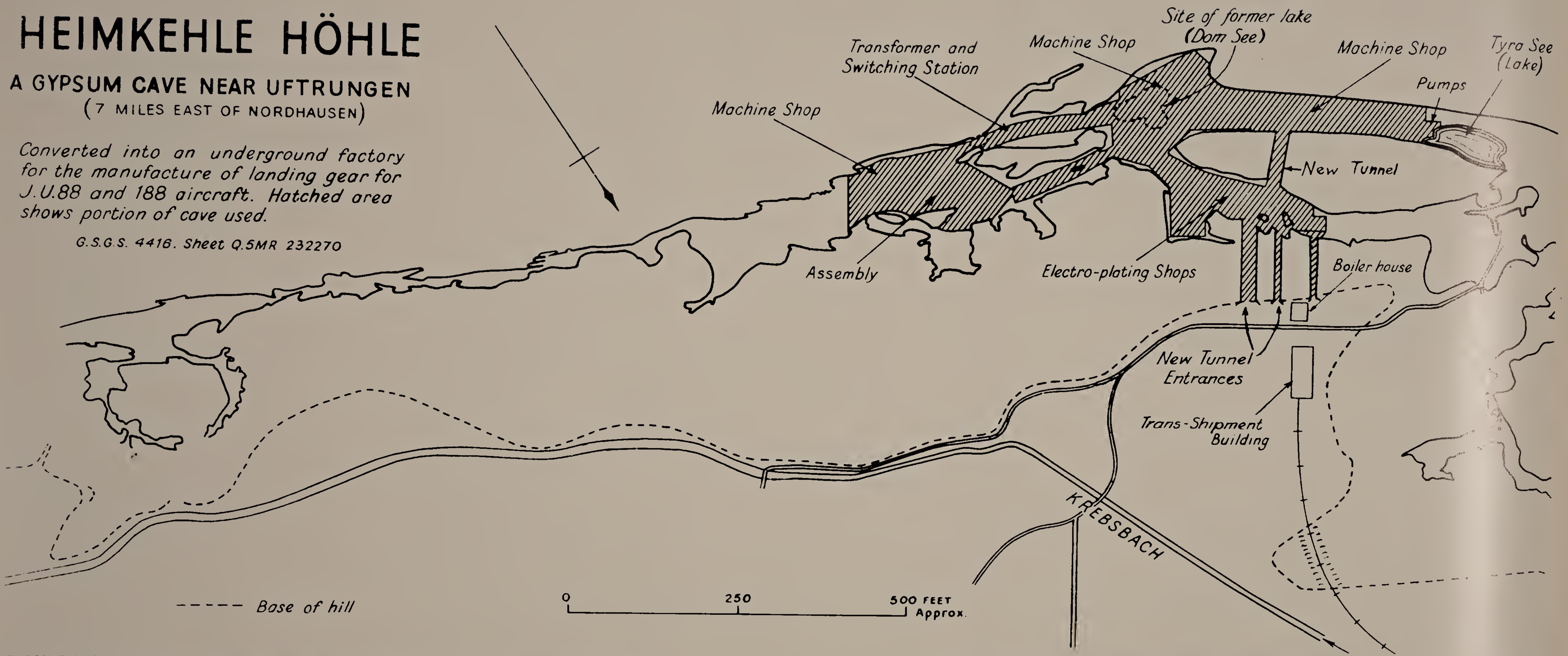

HEIMKEHLE HÖHLE
A GYPSUM CAVE NEAR UFTRUNGEN
(7 MILES EAST OF NORDHAUSEN)
Converted into an underground factory for the manufacture of landing gear for J.U.88 and 188 aircraft. Hatched area shows portion of cave used.
G.S.G.S. 4416. Sheet Q.5MR 232270
Machine Shop
Transformer and Switching Station
Machine Shop
Site of former lake (Dom See)
Machine Shop
Tyra See (Lake)
Pumps
New Tunnel
Assembly
Electro-plating Shops
Boiler house
New Tunnel Entrances
Trans-Shipment Building
KREBSBACH
----- Base of hill
0
250
500 FEET Approx.

FIGURE 168. A plan of the Heimkehle Hoehle, a gypsum cave near Uftrungen, Soviet Zone, Germany. Compare this plan with Figure 167. One of the lakes in the cave was drained and electric pumps were used to pump water out of the cave in order to prevent the factory from being flooded. The floor of the cave was about 15 feet below the level of the adjoining valley. Sheds with wood and tar paper roofs were built inside the cave to prevent water from dripping on the machinery. Plan from Special Report by CIOS Team 163, dated 2 Sept. 1945.

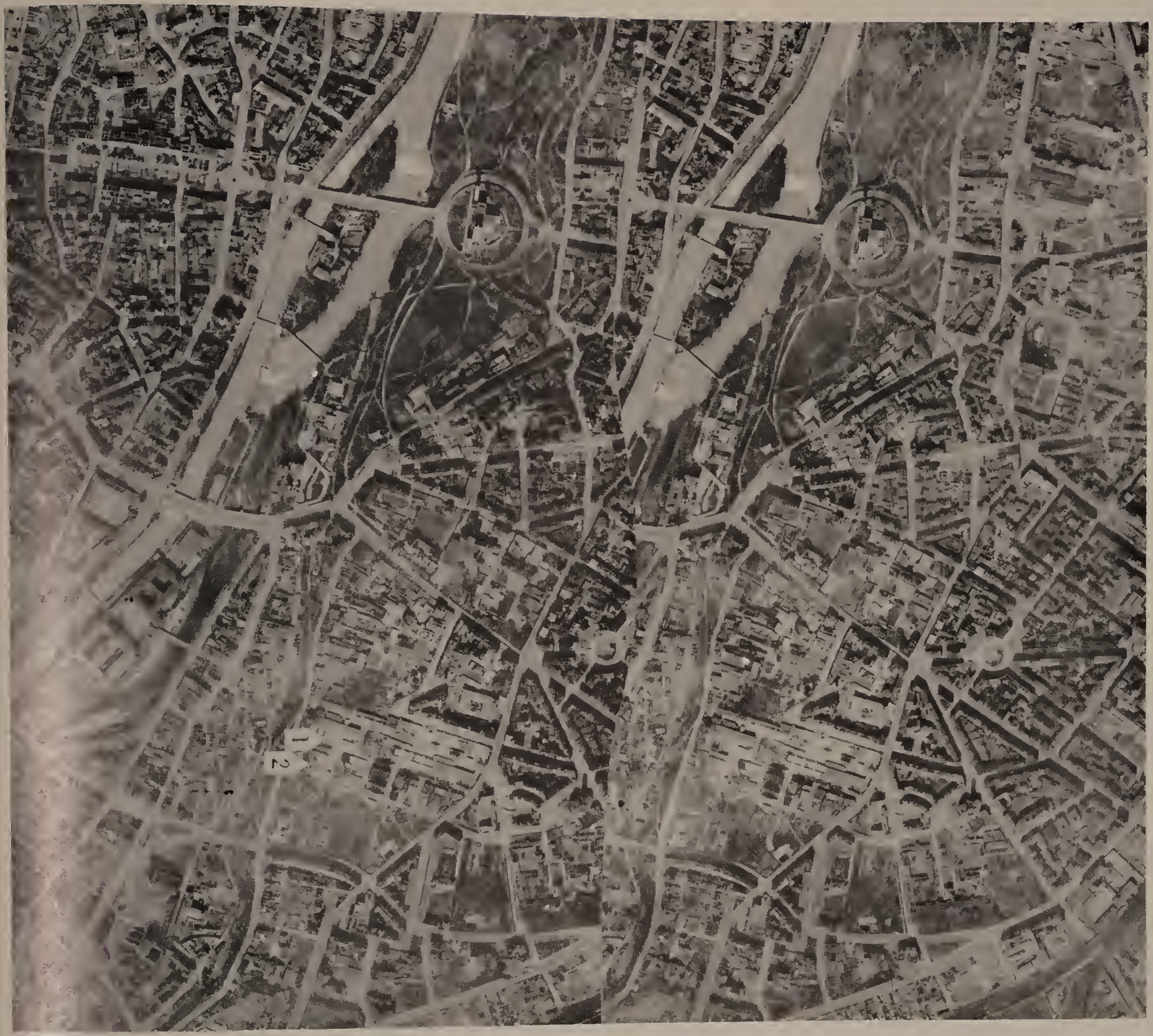


FIGURE 169. Stereogram of the BMW underground factory in the Francis Kanner beer cellar, Munich, U. S. Zone, Germany. This underground plant had a floor space of 21,500 square feet, produced small parts for aircraft engines and employed 450 people. The cellar consists of several tunnel-like rooms 20 to 22 feet wide and up to 185 feet long. These rooms are of brick construction with arched ceilings and are covered by about 10 feet of earth. Several ventilation shafts were built (1). A ground view of four of these is shown in Fig. 170. Part of one room was knocked in by a bomb (2). A ground view of this bomb damage is shown in Fig. 171.

Cover: Prints 3026–3027 of Sortie 32S/995, dated 11 April 1945.

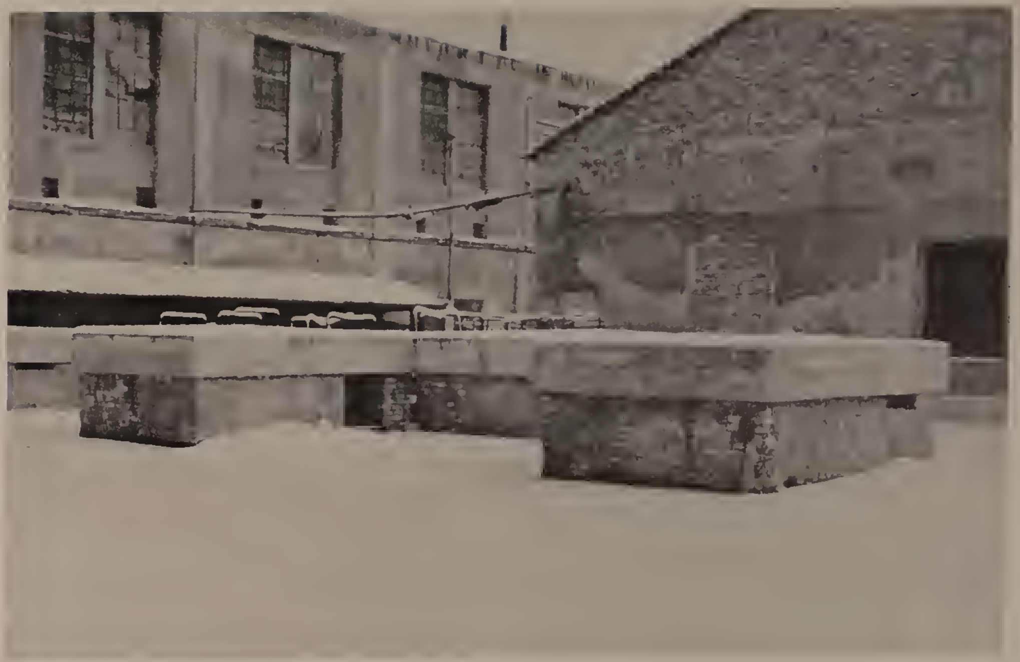


FIGURE 170. View of ventilation shafts at the BMW underground plant in Francis Kanner beer cellar in Munich, U. S. Zone, Germany. Photos by A–2, USAFE, 1946.

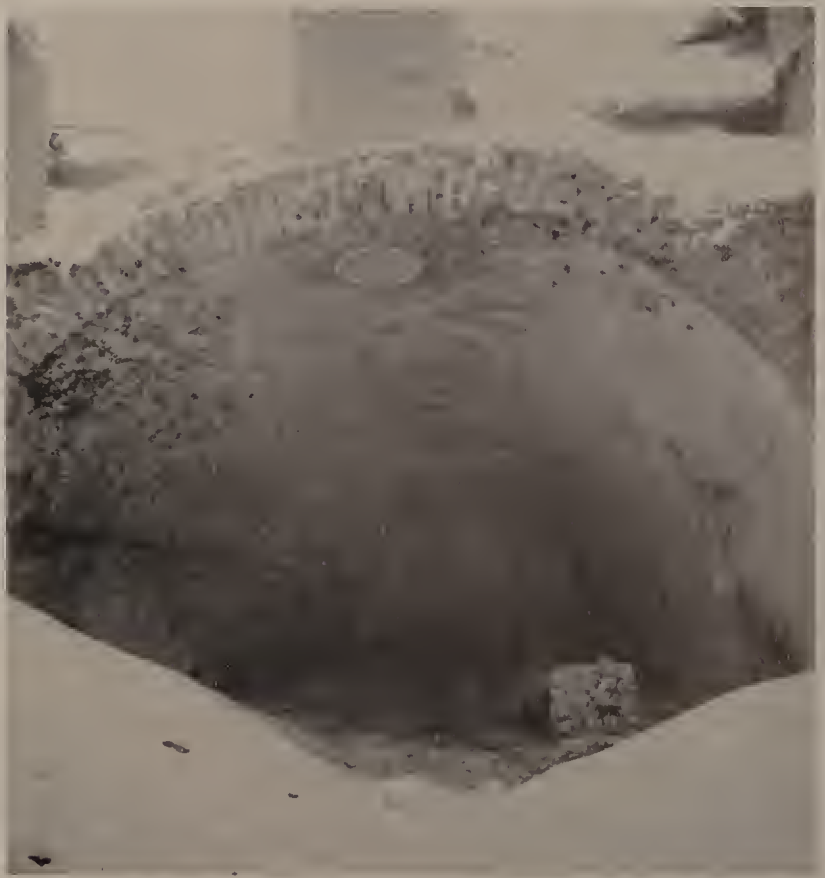


FIGURE 171. View of bomb damage sustained by one room at the BMW underground plant that was built in the Francis Kanner beer cellar in Munich, U. S. Zone, Germany. Photo by A–2, USAFE, 1946.

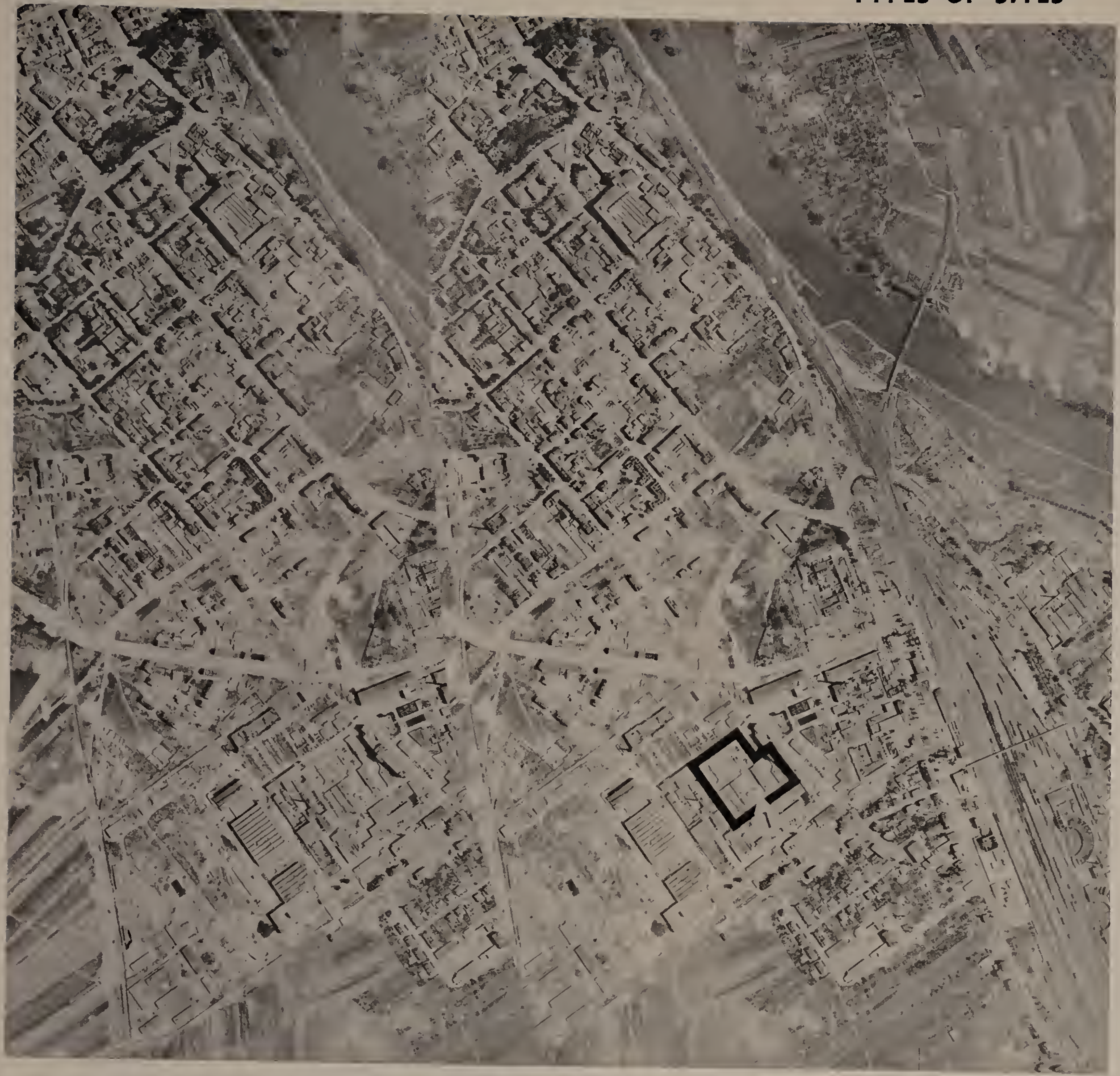


FIGURE 172. Stereogram of the Kugelfischer A.G. ball bearing factory that was moved into the cellar of the bombed-out above ground buildings at Schweinfurt, U. S. Zone, Germany. In the photography shown above a reinforced concrete roof 8.3 feet thick is being built over the cellar (1). The supporting columns were enlarged to 3 feet by 3 feet in cross section and spaced 20 feet apart. The ceiling height was 12 feet. The total cellar floor space was 91,000 square feet. Production in the cellar began in July 1944 and 350 persons were employed.

Cover: Prints 3024–3025 of Sortie US7/2733, dated 6 August 1944.

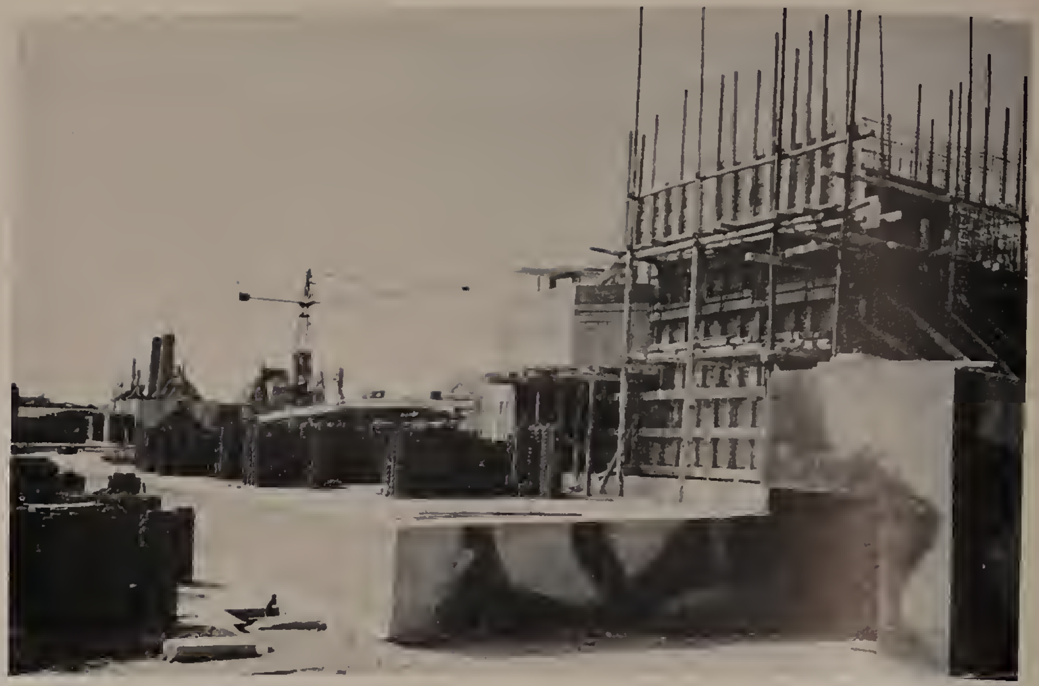


FIGURE 173. View of the concrete roof built on the Kugelfischer cellar-factory at Schweinfurt, shown in Fig. 172. Note the stacks of ball bearing rings, the camouflage paint and the form for additional concrete protective construction. U. S. Army Photo No. ETA–HQ–45–32418.

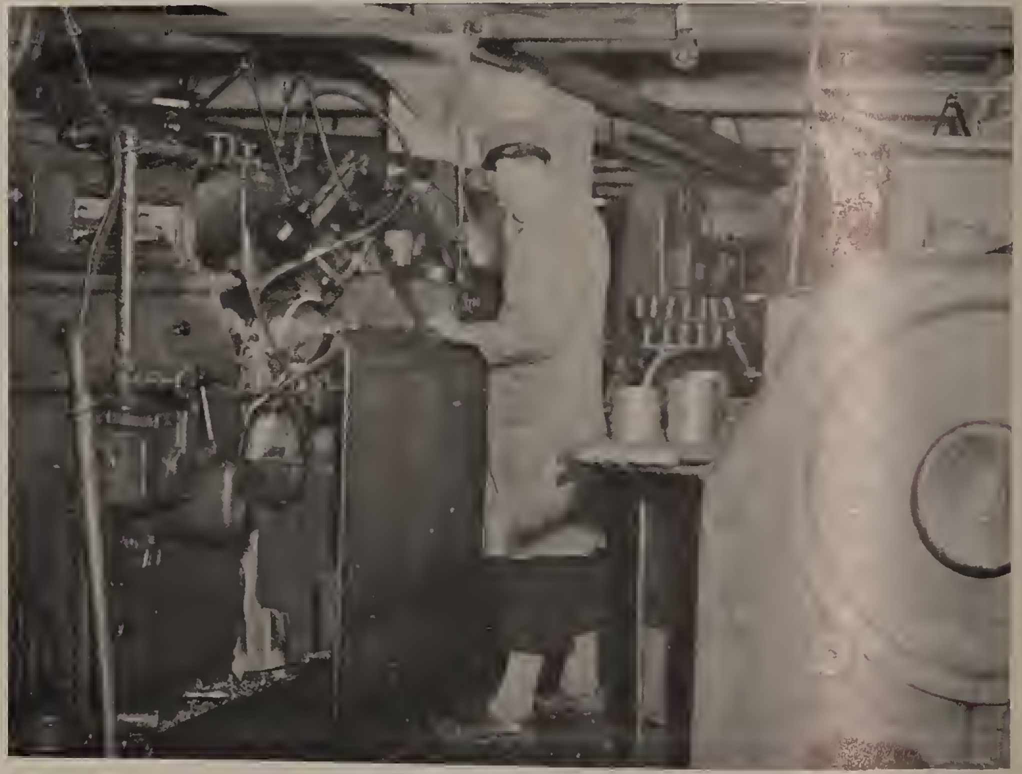


FIGURE 174. Interior view of Kugelfischer's cellar factory at Schweinfurt. An average of 420,000 inner and outer ball bearing rings were produced here per month. Machining and grinding operations were done in the cellar. Hardening operations were done in an above ground building. Photo by A–2, USAFE, 28 February 1946.

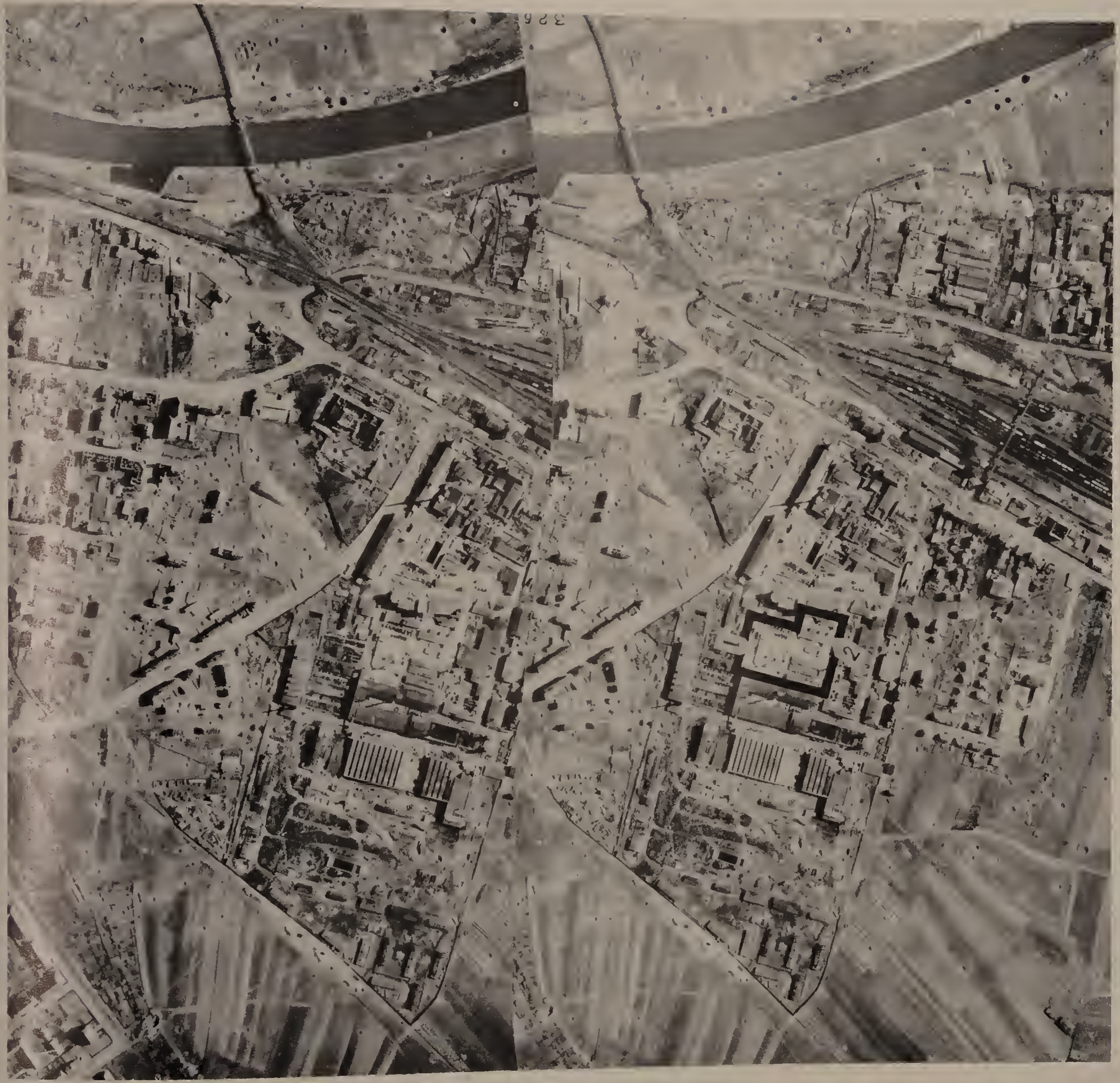


FIGURE 175. Stereogram of the Kugelfischer cellar factory at Schweinfurt. Note the progress of construction during the seven months since the photographs in Fig. 172 were taken. The concrete roof over the factory is now complete (1) and massive concrete structures protecting ventlation openings (2), stairs and elevator shafts have been built or are under construction. Note the activity in the area and that several above ground buildings have been repaired.
Cover: Prints 3133–3134 of Sortie 106G/4870, dated 16 March 1945.

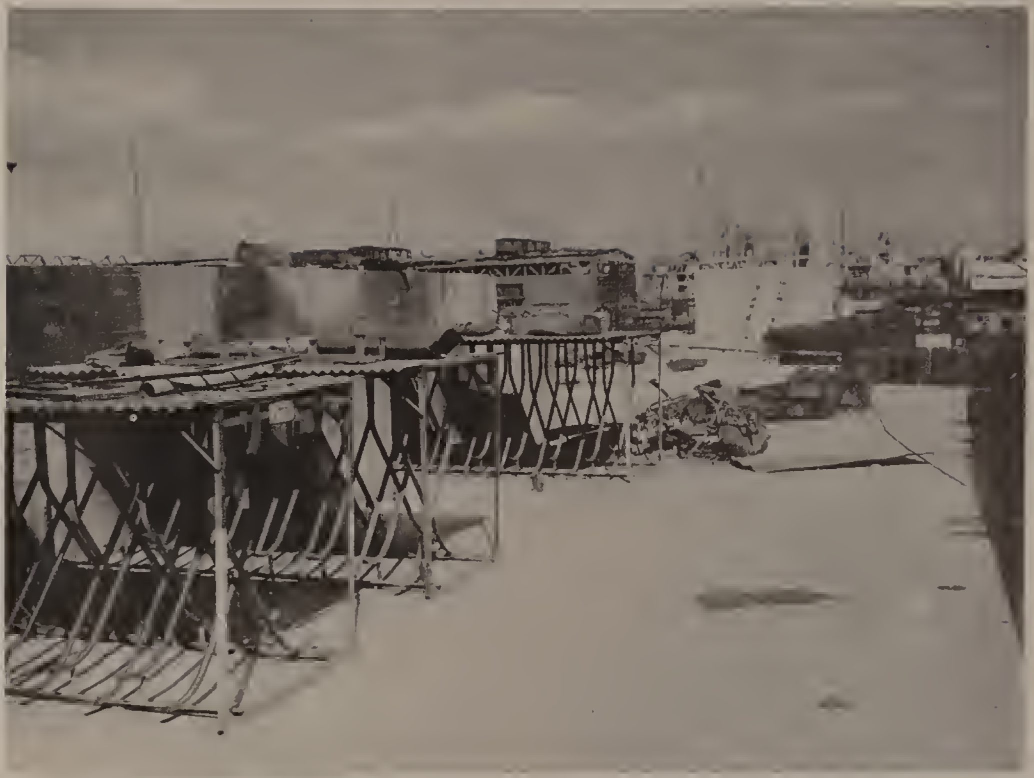


FIGURE 176. View on top of the Kugelfischer cellar factory at Schweinfurt, shown in Fig. 175. The objects in the foreground are bicycle racks. Note the debris scattered around to give the appearance of disuse. Note paint camouflage on the concrete ventilation bunker at the left. U. S. Army Photo No. ETO–HQ–45–32417.

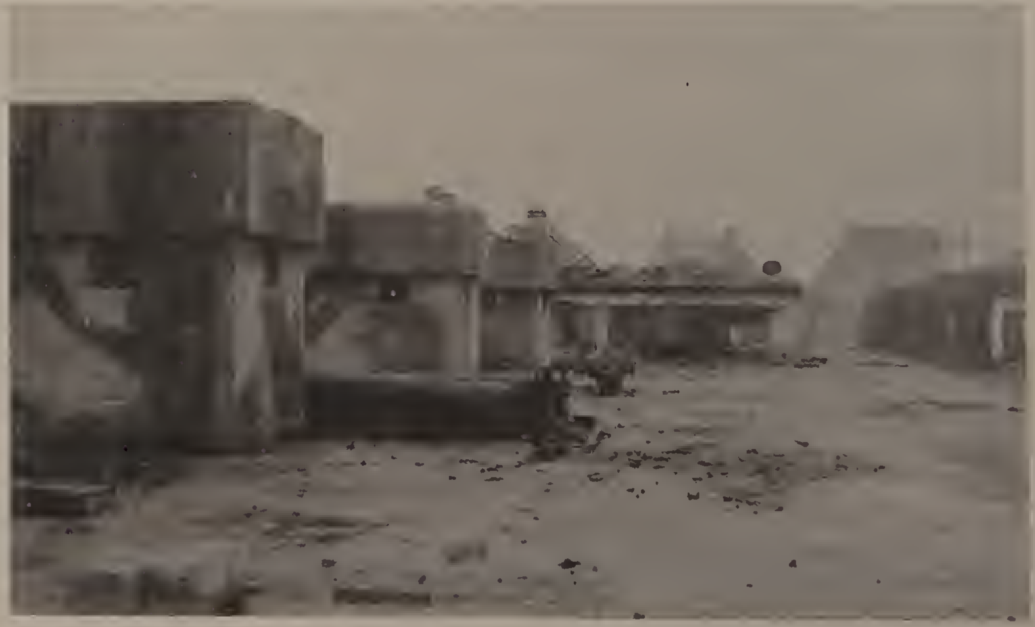


FIGURE 177. View of three bomb proofed fresh air inlets on top of the Kugelfischer cellar factory at Schweinfurt. Note the paint camouflage on these massive concrete structures. Note the appearance of these box-like objects in Fig. 175. Photo by A–2, USAFE, Feb. 1946.

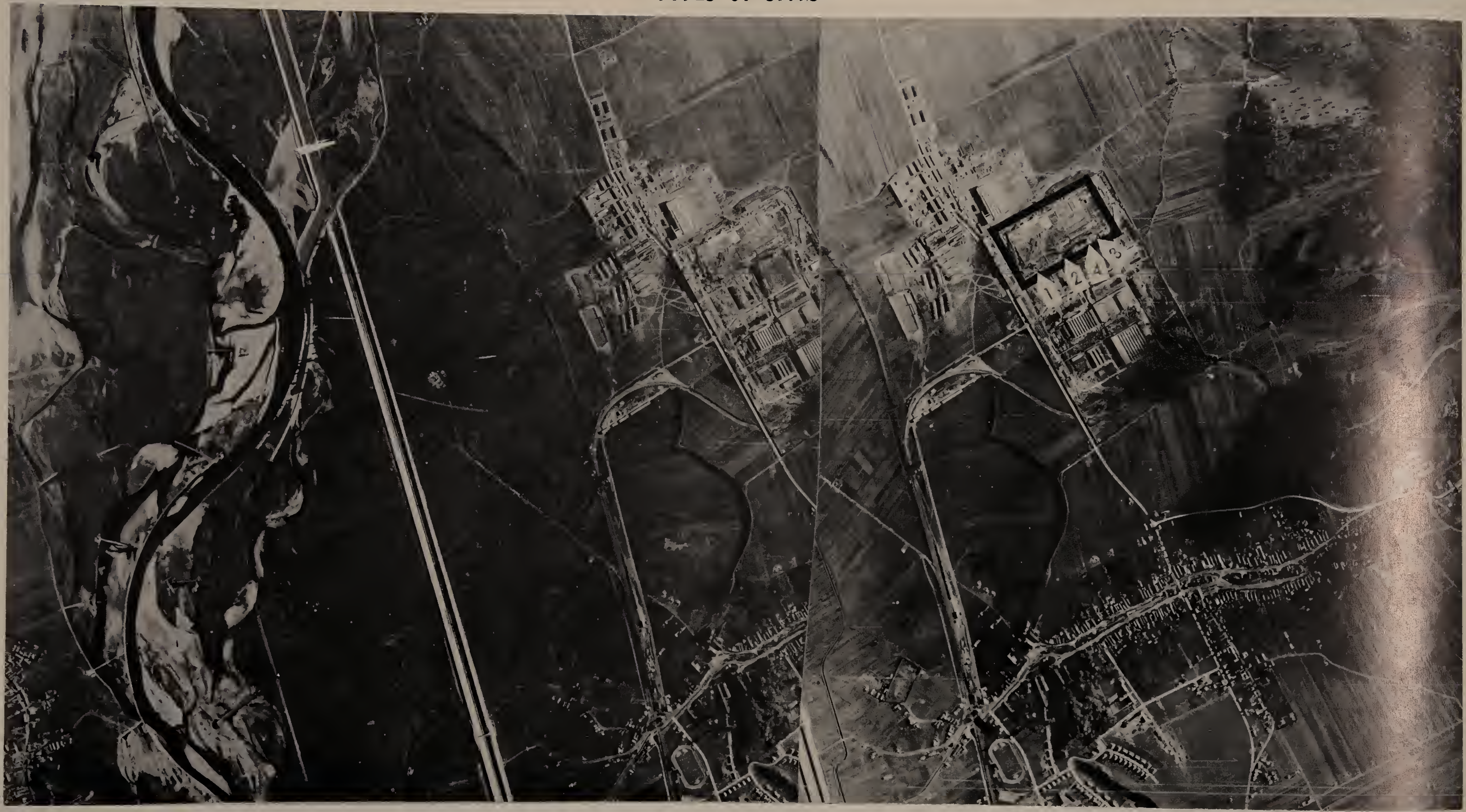


FIGURE 178. Stereogram of the flat-top concrete bunker at Dubnica, Czechoslovakia. This armament factory was built for the Skoda Works in 1936 by excavating a pit approximately 980 feet long, 330 feet wide and 45 feet deep and lining it with walls of concrete and roofing it over with a layer of concrete 10 feet thick. The Germans added a second layer of concrete. On top of the concrete was a layer of earth 13 feet thick. In 1946 the Communists were reported to be adding still another layer of concrete. The factory contained between 577,500 and 630,000 square feet of floor space on three levels. Under the Germans this factory produced DB 603 aircraft engines. Under Communist control it is reported to be producing artillery gun barrels or tubes. Note that the bunker extends above the level of the ground and that there are three entrances for standard gauge railway cars (1–3). This semi-underground factory had its own power plant operated by steam generators. Steam also was used to operate the presses. The power plant was primarily for use in emergencies but produced enough power to operate the plant if the heat treating furnaces were not operated at full capacity. Note the cooling tower (4) and the chimneys near the entrances.

Cover: Prints 4094–4095 of Sortie SA 60/784, dated 13 October 1944.

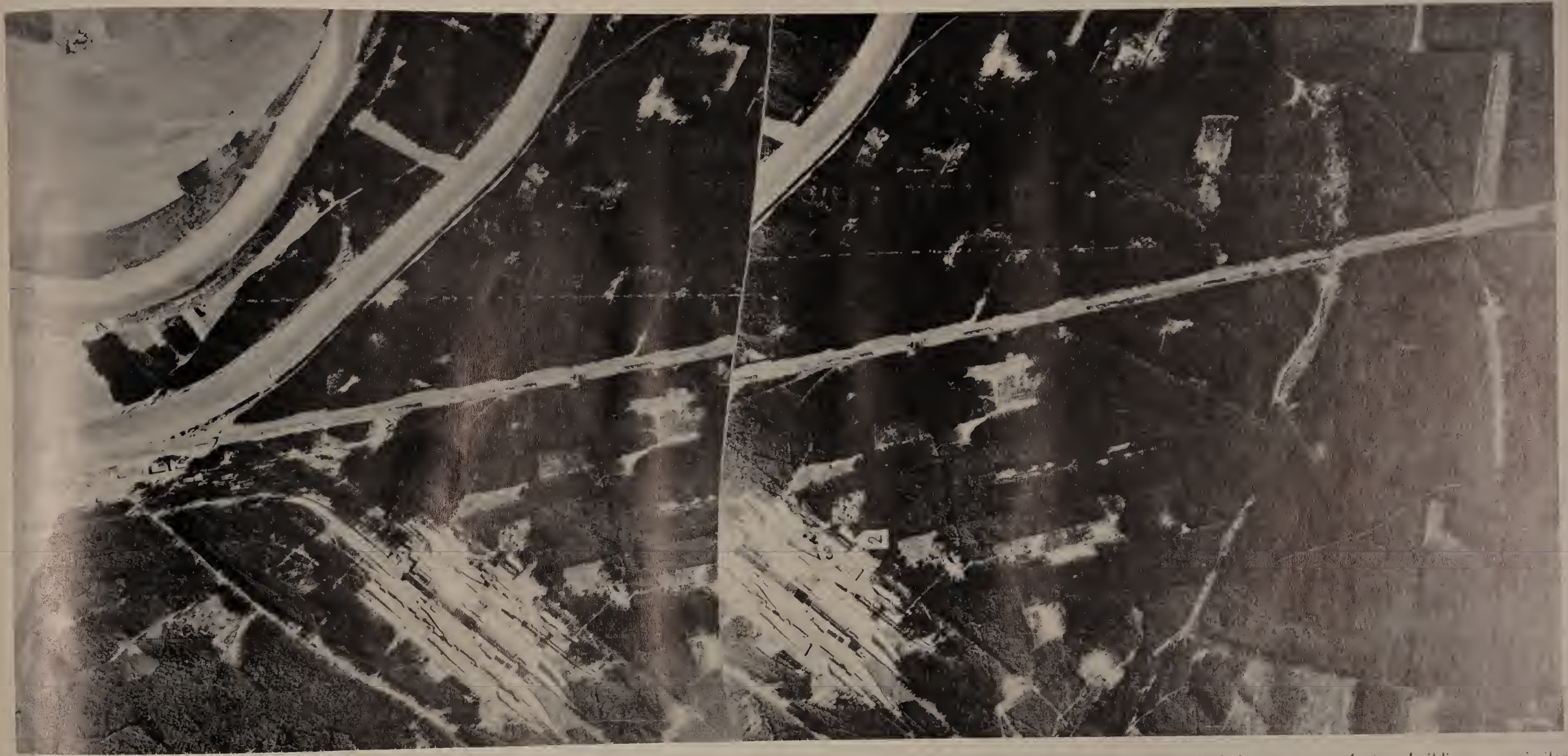
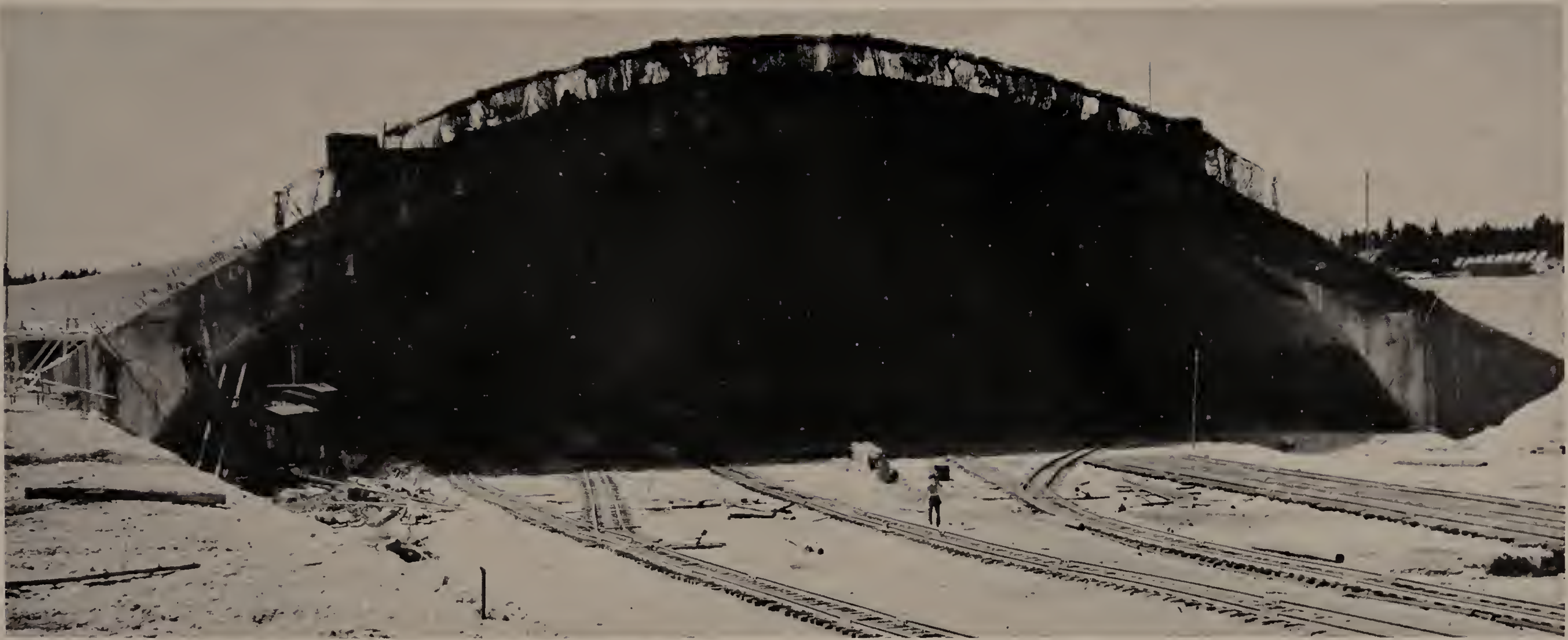


FIGURE 179. Stereogram of the semiunderground reinforced concrete arch-shaped bunker near Muhldorf, U. S. Zone, Germany, while under construction. This standardized factory building was to be 80 feet high, 1200 feet long and 260 feet wide at the base. It was to extend 50 feet below ground level and 30 feet above ground. The roof was to be 16 feet thick. There were to be 8 floors and the total floor space planned was to be approximately 2,496,000 square feet. This Bunkerwerk (bunker factory) originally was intended to house an aircraft factory for the production of the Me 262 jet fighter but later it was decided to install a synthetic rubber plant, a tire plant and an ammonia plant instead. No production was obtained. There were 12 of these Bunkerwerke planned and 6 were under construction when the war ended. The roof thickness was originally planned to be about 10 feet but the advent of larger British bombs caused a continual upward revision of the thickness estimated as necessary for safety and by the end of the war a thickness of 30 feet was envisaged. The construction of all of these concrete factory buildings was similar. First, a central ditch was dug in which a tunnel made of prefabricated concrete blocks was built. This tunnel was large enough for railway tracks and trains of gravel cars. Next, two paralel trenches were dug for the foundations of the concrete arch and the gravel from these was piled over the central tunnel as a form or support for the initial layers of concrete. After sufficient concrete had been poured for the arch to be self supporting the gravel was removed and construction work on the inside began. Several stages of construction took place simultaneously as can be seen above. The square structures built into the foundations are for ventilation (1). Concrete was mixed in a building off to one side (2) and pumped over to the bunker through a pipe (3).

Cover: Prints 3044–3045 of Sortie SA 60/1003, dated 16 February 1945.



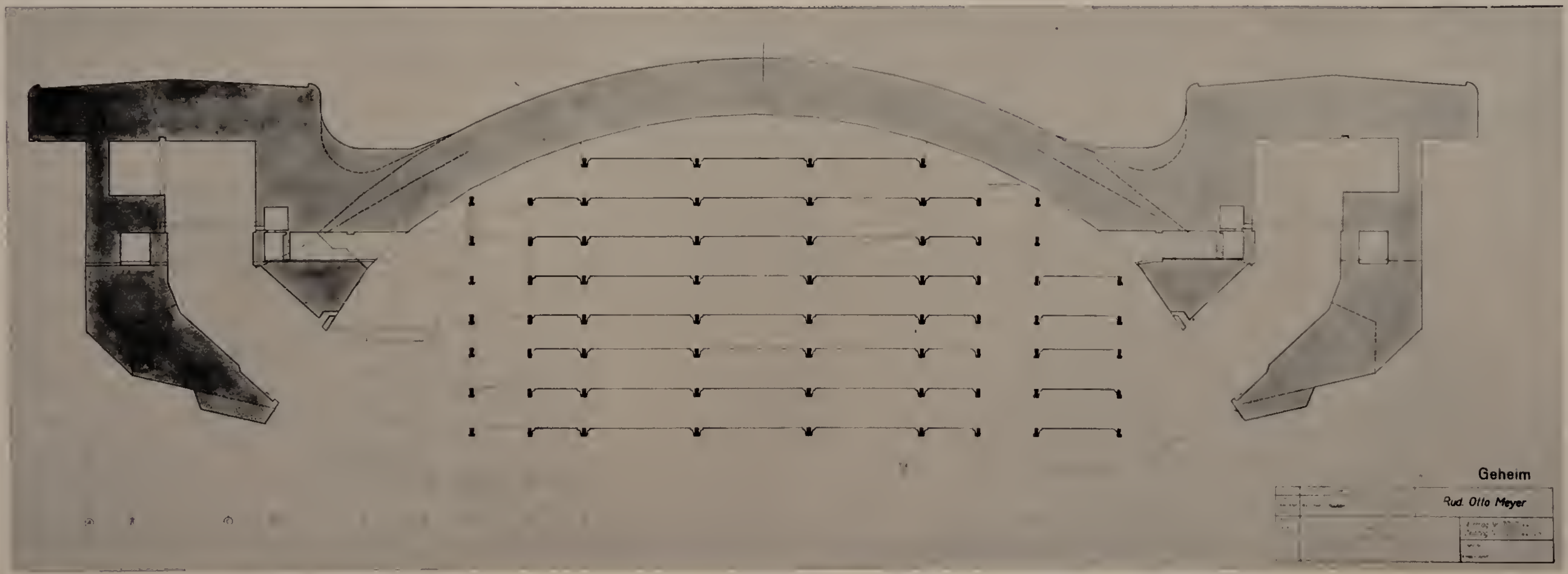


FIGURE 181. Cross section of the bunker factory at Muhldorf, U. S. Zone, Germany, as planned. See Figs. 179 and 180. This section is drawn through two of the ventilation ducts. Note the number of floors, the outline of the foundations and the location of the ground level.

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